BUTTER

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BY

CLAIRE C. TOTMAN
Division of Agriculture, South Dakota State College

THE LATE G. L. McKAY

AND

CHRISTIAN LARSEN
Dean of the Division of Agriculture, South Dakota State College

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FORMERLY
"PRINCIPLES AND PRACTICE OF BUTTER-MAKING"
BY
G. L. McKAY AND CHRISTIAN LARSEN

FOURTH EDITION

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PREFACE TO FOURTH EDITION

This revision of *Principles and Practice of Buttermaking* has been made with the idea of providing a textbook for undergraduate instruction and also of furnishing useful information to plant operators and others connected with, or interested in, the subject.

No effort has been made to treat exhaustively the various related topics. Rather, it has been our aim to provide the essentials of the subject, and only to suggest intensive study of various phases by reference to the original literature in the form of experiment-station bulletins, reports of proceedings of the many trade and technical associations, and research by the industries themselves, both manufacturers of butter and manufacturers of dairy equipment. Research in nutrition, bacteriology, chemistry, refrigeration, and other allied subjects proceeds apace, and inclusive presentation in a single book becomes impractical. In this book, the information for plants handling whole milk is somewhat restricted because many dairy products are made in one factory and the manager must have literature relating to those special products.

This book on buttermaking has been entirely rewritten except for part of Chapter 3, "Milk and Its Products as Foods," and the entire Chapter 4, "Variations of Fat in Milk and Cream." Considerable information is presented in graphical form because we believe graphs facilitate instruction and retention of the facts so presented. Three phases of the butter industry are treated more fully than others because of their relative importance in successful plant operation. These are: (*a*) buying and grading of cream; (*b*) churning—working of butter and composition control; and (*c*) marketing.

Thanks are due Dr. N. E. Fabricius of Iowa State College and Professor L. C. Thomsen of the University of Wisconsin for reviewing the greater portion of the manuscript and offering valuable suggestions and criticisms. To research and experiment-station workers, from whose contributions a major part of the text material has been gathered and who have been helpful in many instances through personal correspondence, our thanks. We thank the Creamery Package Manufacturing Company, the Cherry-Burrell Corporation, the Chester Dairy Supply Company, Land O' Lakes, Inc., the Chris Hansen Laboratory, Inc., the Jensen Creamery Machinery Company, the General Dairy Equipment Company, the Kimble Glass Company, and others who have contributed directly or indirectly. We extend thanks, also, to the Bureau of Dairying and the Bureau of Agricultural Economics of the United States Department of Agriculture for supplying charts, statistics, and other information.

It is our hope that this revision will prove useful to all who are interested in the dairy industry. An effort has been made to retain the usefulness of previous editions.

C. C. TOTMAN
C. LARSEN.

BROOKINGS, SOUTH DAKOTA
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BUTTER

CHAPTER 1

HISTORY OF BUTTERMAKING

Centuries ago, man discovered that agitation of milk or cream caused the formation of visible clusters of butterfat or milk fat. The use of milk as a food dates from the domestication of animals, and many species have furnished milk for man. The cow has always held the premier position as a source of milk. The goat, the sheep, and the buffalo have supplied milk and still do in some sections of the world where population is dense or where special types of dairy products are made. For example, in France where the manufacture of Roquefort cheese is regulated by law, the milk of sheep and goats must comprise 90 per cent of the total.

Butter first had several uses other than food. It served as a cosmetic, being used on the skin and hair. It was also a tonic. Later it was used more extensively in the cooking and preparation of foods.

Butter was made by beating milk in open bowls. Primitive churns consisted of leather bags or hollowed logs swung from trees. Civilization developed small family churns of the dasher, oscillating, or revolving type. Buttermaking remained largely in the household in the United States until between 1880 and 1890. The first cream separators were imported shortly after 1880. Although their introduction was slow, creameries were established and whole milk was delivered to these factories. The creameries furnished a definite stimulus to milk production. Much hand labor on the farm was eliminated and a cash market for milk was provided. Since that period there has been a continuous and very rapid shift from farm buttermaking to factory buttermaking. (See Chapter 22, "Dairy Production and Statistics.")

The invention of the Babcock test for butterfat in 1890 further stimulated milk and cream production, and the creamery industry developed rapidly. It is of interest to note here that the first centrifugal cream separator used in Iowa was one which Jeppe Slipsgaard brought with him from Denmark in 1882 to a Danish community in Black Hawk County near Cedar Falls, Iowa. As further

Fig. 1. The original Babcock tester, introduced in 1890. The mechanism was made from parts of an old DeLaval cream separator.

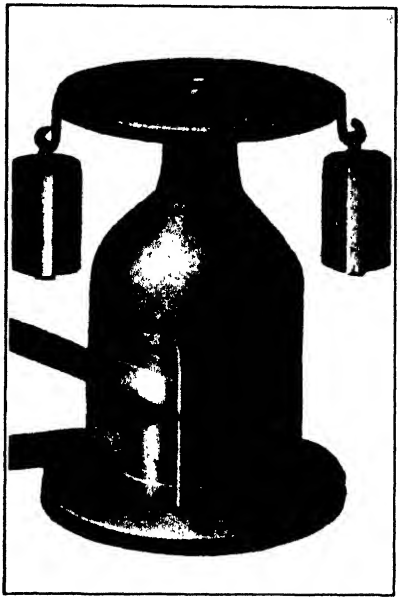


Fig. 2. Lefeldt's cream separator of 1874, made in Germany. One of the earliest attempts to use centrifugal force to separate cream from milk. The two pails of milk were whirled a few minutes, the machine stopped, and the cream removed by hand from the top of the pail. Photograph courtesy of the Bureau of Dairy Industry.

evidence of the fact that these machines were very new, the customs officials in New York held this machine two months before they decided whether it was made of iron or steel. Finally they decided it was of steel construction and levied a duty of $93.00.

Continuous improvement of creamery equipment and methods of manufacture have placed the butter industry on a technically controlled basis today. The art of buttermaking is fast becoming obsolete. The modern buttermaker must be technically trained and must be precise in his control of factory operations. Developments in sanitation, pasteurization, refrigeration, transportation, and marketing facilities have all played a part in the status of the industry of today.

These data, adapted from the U. S. D. A. Yearbook, are given to show the extent of creamery-butter production in the various states and regions. Refer to Chapter 22 for map giving similar data. It is very interesting also that seven states in the West North Central

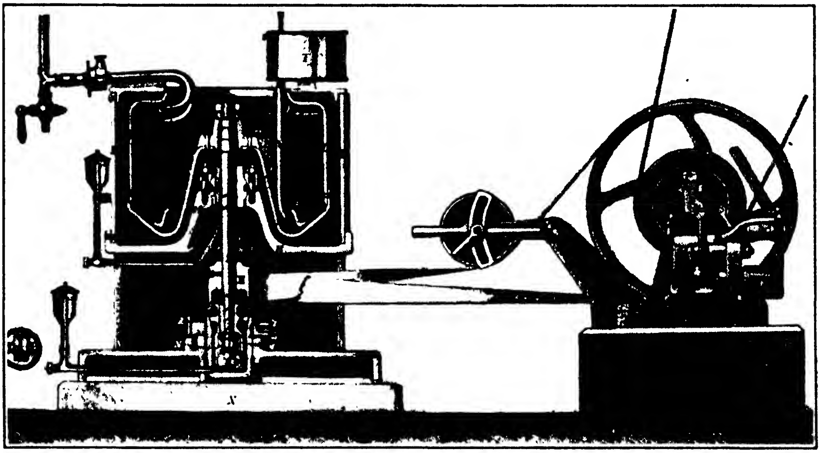


FIG. 3. One of the first cream separators using a bowl and similar to Lefeldt s "eiserner trommel" or iron bowl separator. It operated with continuous flow. Photograph courtesy of the Bureau of Dairy Industry.

Region produce one-half the total market butter. Minnesota leads all states, producing 289,830,000 pounds in 1936, which is 15 per cent of the total United States production. Iowa is second with 208,926,000 pounds and Wisconsin is third with 171,400,000 pounds. These figures for 1936 are higher for Minnesota, Wisconsin, and lower for Iowa than the data given for 1932 in the table on page 4. These three states have led all others in butter production and, for some time, have ranked in the order given.

In the early days, before the establishment of "butter factories," butter was made on the farm and marketed in stone jars. The butter was credited toward groceries in the way that eggs were. Eggs

Creamery-Butter Production by States (1935)

Region	State	Pounds (000 omitted)	Total Pounds
North Atlantic	Maine	21	4,106,000
	New Hampshire	......	
	Vermont	2,817	
	Massachusetts	1,050	
	Rhode Island	19	
	Connecticut	199	
Mid Atlantic	New York	14,034	26,349,000
	New Jersey	33	
	Pennsylvania	12,282	
East North Central	Ohio	82,640	465,282,000
	Indiana	73,935	
	Illinois	71,360	
	Michigan	77,439	
	Wisconsin	159,908	
West North Central	Minnesota	272,585	799,629,000
	Iowa	217,810	
	Missouri	87,438	
	North Dakota	39,726	
	South Dakota	36,122	
	Nebraska	76,400	
	Kansas	69,548	
South Atlantic	Delaware	30	13,179,000
	Maryland	1,239	
	Virginia	6,353	
	West Virginia	356	
	North Carolina	2,433	
	South Carolina	724	
	Georgia	1,805	
	Florida	239	
South Central	Kentucky	21,950	117,449,000
	Tennessee	15,920	
	Alabama	1,486	
	Mississippi	6,631	
	Arkansas	5,503	
	Louisiana	1,519	
	Oklahoma	38,674	
	Texas	25,766	
	Mountain		
Western	Montana	12,577	74,792,000
	Idaho	28,452	
	Wyoming	2,144	
	Colorado	18,261	
	New Mexico	1,152	
	Arizona	1,941	
	Utah	8,788	
	Nevada	1,477	
	Pacific		
	Washington	37,299	131,594,000
	Oregon	29,918	
	California	64,377	

It is of interest to note the following:

Region	Creamery-Butter Production in United States
West North Central	50% (7 states)
West North Central, East North Central	77% (12 states)
Minnesota alone	17% (1 state)

Region	Creamery-Butter Production in United States
West North Central, East North Central, Pacific Coast	85.5% (15 states)

are still marketed in the same manner in some sections, but the making and marketing of butter has become a factory job. This was inevitable. The growth of cities meant the adoption of some means of making, marketing, storage, and distribution of butter on a scale which would supply this staple food in a pure, wholesome, sanitary condition.

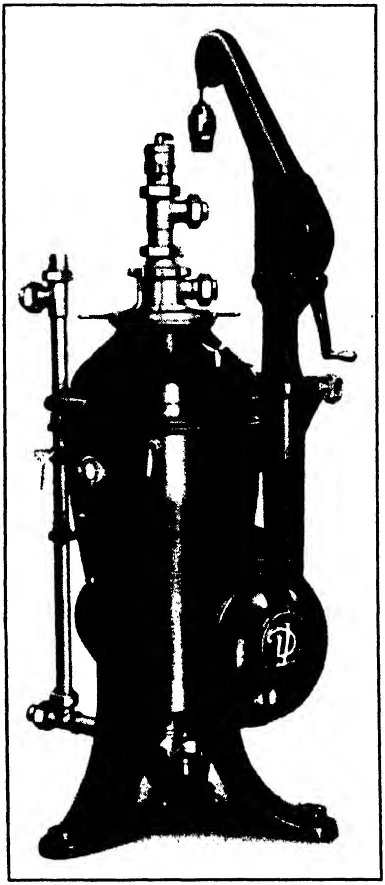


FIG. 4. Modern DeLaval motor-driven cream separator. It is of so-called "air-tight" construction, which eliminates foam formation. No drive belts are used, the power being transmitted to the separator gears through a special slip clutch arrangement. Courtesy of DeLaval Separator Co.

The amount of factory-made butter has increased rapidly since 1910. Simultaneously there has been about a 50 per cent reduction in farm-made butter. It is interesting to note that in 1934 more than 500,000,000 pounds of butter were still made on farms. See Fig. 5.) This is about 25 per cent of the total 2,250,000,000-pound annual production. The southern states produce more farm-made butter than other sections.

Pasteurization of cream for buttermaking and the development of artificial refrigeration have so regulated the keeping quality of butter that, although it may be classed as a perishable food product, it is nevertheless stored satisfactorily for periods of six to twelve months and then delivered to the consumer in excellent condition. Modern refrigeration permits the transportation of butter in international commerce. London is the world's butter market. Butter from several European countries is sold in London. It is of interest that England gets about one-third of its butter from Australia, New Zealand, and Argentina.

At least six weeks are required for New Zealand butter to arrive in London. The quality of cream must be good, the cream and butter must be carefully processed, and adequate refrigeration must be provided to insure delivery of a good product to the London market.

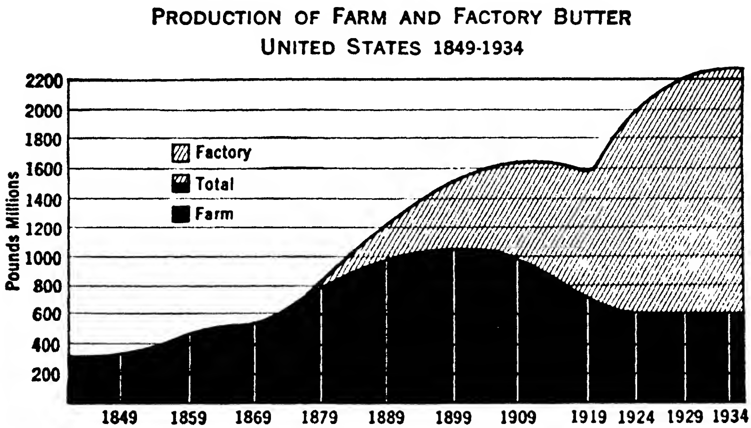


FIG. 5. Relative amounts of farm- and factory-made butter. The southern states still have considerable amounts of farm-made butter. From "Elements of Dairying," by T. M. Olson. Courtesy of The Macmillan Co.

The reader is referred to Chapter 22, "Dairy Production and Statistics," for further details on the growth of the butter industry and the part refrigeration and storage have played in its development.

The following tables show international movements of butter.

Butter: Imports of Various Countries

From U. S. D. A., Bureau of Agricultural Economics

Importing Country	1932	1933	1934	1935	1936	1937 [1]
	1,000 Pounds	1,000 Pounds	1,000 Pounds	1,000 Pounds	1,000 Pounds	1,000 Pounds
United Kingdom	902,601	979,553	1,074,771	1,061,827	1,082,967	1,041,843
Germany	153,262	130,389	136,164	156,527	166,242	191,436
Switzerland	8,152	1,146	652	302	3,223	5,624
United States	1,014	1,022	1,253	22,675	9,874	11,111
Belgium	46,928	27,408	20,692	13,304	8,141	4,969
France	26,140	20,307	9,604	1,510	4,251	1,495
Netherlands India	11,711	13,178	13,581	13,587	12,291	7,244 [2]
Irish Free State	2,632	22	83	41	10	......
Canada	238	1,377	2,874	149	117	66
Austria	802	161	158	17	13	12
Netherlands	9,321	1,449	1,173	429	71	99
Australia [4]	1	4	2	2	4	2
Czechoslovakia	2,704	1,494	2,228	2,928	496	1,675
Norway	91	146	4	5	......	......
Egypt	1,545	1,807	1,893	1,897	2,412	2,038
Cuba	58	12	15	24	25	......
Union of South Africa	1,110	2,640	2,897	1,947	2,644	5,824
Denmark	923	783	......	......	185	−175 [3]
Algeria	3,939	4,105	4,790	4,767	4,394	......
China	1,423	1,547	1,645	1,764	939	825
Peru	211	161	202	275	339	388
British Malaya	1,621	1,585	1,841	2,153	2,344	2,327
Trinidad and Tobago	1,024	1,217	1,561	1,260	1,753	......
Philippine Islands	1,336	1,356	1,690	1,570	1,580	1,325
Sweden	32	73	4	1,340	414	1
Greece [4]	1,198	604	689	1,015	781	687
Italy	3,817	2,360	3,311	929	940	5,114
Poland	866	25	10	1	......	......
Hungary	......	......	......	......	......	......
Spain	41	15	144	78	......	......
Finland	......	1,408	13	......	......	......
Argentina	6	2	2	249	2	2

Calendar years.
Official sources unless otherwise indicated.
[1] Preliminary.
[2] Java and Madura only.
[3] Excess of re-exports over imports.
[4] International Yearbook of Agricultural Statistics.

Butter: Exports of Various Countries

From U. S. D. A., Bureau of Agricultural Economics

Exporting Country	1932	1933	1934	1935	1936	1937 [1]
	1,000 Pounds	1,000 Pounds	1,000 Pounds	1,000 Pounds	1,000 Pounds	1,000 Pounds
Denmark	347,882	332,265	330,307	305,019	322,322	337,107
New Zealand	244,781	295,148	292,826	312,401	313,168	333,322
Australia [3]	229,055	211,527	246,778	256,765	185,634	182,913
Netherlands	44,922	62,551	81,320	103,146	132,684	118,645
Russia [2]	68,197	82,022	83,559	64,800	51,096	32,236
Argentina	55,915	30,659	18,347	14,947	22,639	19,359
Irish Free State	36,931	45,232	56,886	59,470	58,033	42,564
Sweden	29,866	37,758	51,191	44,669	42,037	51,885
Finland	32,020	26,201	24,467	22,581	30,836	30,732
Latvia	41,001	34,494	34,614	37,073	38,119	42,353
Canada	3,506	4,437	428	7,697	5,129	4,097
Estonia	27,626	20,336	22,306	23,893	24,152	29,056
France	7,024	6,062	7,297	11,605	12,680	6,629
Poland	2,707	3,547	9,782	12,535	24,045	17,878
United States	1,605	1,191	1,220	958	826	800
Italy	827	834	276	437	1,222	1,501
United Kingdom	1,238	1,328	1,477	1,398	1,233	1,408
Belgium	1,841	725	108	70	68	44
Yugoslavia	339	318	364	362	269	225
Union of South Africa	4,328	2,508	2,855	8,929	9,307	7,215
Spain	45	21	15	26	....	..
Hungary	..	.	..		..	.
Austria	1,565	2,606	7,052	5,687	7,801	7,637
Norway	2,429	904	547	416	424	443
Czechoslovakia	27	109	23	6	379	1,587
Germany	478	19	8	13	..	....
British Malaya	108	118	155	280	393	359
Switzerland	7	2	1	4	6	8
Egypt	389	254	85	133	43	14
Algeria	36	17	8	25	10	......

Official sources unless otherwise indicated.
Calendar years.
[1] Preliminary.
[2] Union of Soviet-Socialist Republics.
[3] International Yearbook of Agricultural Statistics.

Ash or Mineral Constituents

Major components:
- *a.* Calcium.
- *b.* Phosphorus.
- *c.* Potassium.
- *d.* Sodium.
- *e.* Sulphur.

Lesser amounts of:
- *a.* Copper.
- *b.* Iron.
- *c.* Zinc.
- *d.* Manganese.
- *e.* Aluminum.
- *f.* Silicon.

Also present and combined with minerals are chlorine, iodine, and citric acid.

Other Constituents

Vitamins:
A, B, C, D, E, F, G, B_2.

Enzymes:
- *a.* Galactase.
- *b.* Catalase.
- *c.* Peroxidase.
- *d.* Lipase.
- *e.* Lactase.
- *f.* Reductase.
- *g.* Diastase.
- *h.* Oleinase.
- *i.* Phosphatase.

Pigments:
- *a.* Carotene (fat-soluble).
- *b.* Lactochrome or lactoflavin (water-soluble).

Gases:
Carbon dioxide, oxygen, nitrogen.

Unidentified Elements. Human milk may possess the property of transmitting a degree of immunity to breast-fed babies. Such immunity against several children's diseases is not positive. It has been theorized that antibodies are transmitted through mother's milk. Likewise, it has been frequently observed that sucking pigs may escape cholera and contract it after weaning.

Jones and Simms [1] describe a substance in milk which they term lactenin. They show how it inhibits bacterial growth for a six-hour period. It is found in whey as well as in milk.

BUTTERFAT

Chemical Construction of Butterfat. We outline here a partial structural formula of one of the fats of butterfat because:

1. Of its relation to lecithin.
2. Lecithin is an important constituent of milk.
   - *a.* It is the precursor of trimethylamine, the fishy-flavored substance in butter.
   - *b.* It causes higher fat test readings in non-acid tests than the standard Babcock test.

Butterfat is formed in this way:

$$\text{Glycerin} + 3 \text{ fatty acid molecules} = \text{butterfat} + \text{water}$$

$$\left.\begin{array}{l} CH_2\underline{OH} \\ CH\underline{OH} \\ CH_2\underline{OH} \end{array}\right\} \begin{array}{l} + \underline{H}OOCC_{15}H_{31} \text{ (palmitic acid)} \\ + \underline{H}OOCC_{17}H_{33} \text{ (oleic acid)} \\ + \underline{H}OOCC_3H_7 \text{ (butyric acid)} \end{array} = \left\{\begin{array}{l} CH_2OOCC_{15}H_{31} \\ CHOOCC_{17}H_{33} \\ CH_2OOCC_3H_7 \end{array}\right. \begin{array}{l} \quad H\cdot OH \\ +\,H\;OH \\ \quad H\cdot OH \end{array}$$

The underscored OH and H ions are set free when glycerin is combined with three molecules of fatty acids, and the butterfat molecule and water are formed. This procedure is reversed when butterfat is hydrolized to form free fatty acids and glycerin, as when butter becomes rancid.

Saponification of Butterfat. Butterfat in cream may be partially saponified by faulty neutralization.

This may be caused by:

1. Too much alkali or neutralizer.
2. Neutralizer too concentrated.
3. Application too rapid.
4. Faulty agitation of cream.

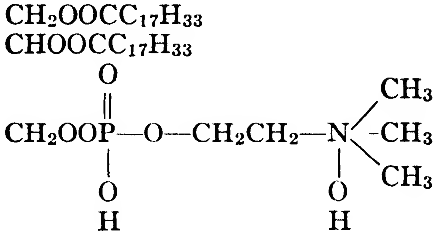
The following equations indicate what may occur:

$$\text{Butterfat} + \text{sodium hydroxide} = \text{glycerin} + 3 \text{ molecules of sodium soaps}$$

$$\left.\begin{array}{l} CH_2OOCC_{15}H_{31} \\ CHOOCC_{17}H_{33} \\ CH_2OOCC_3H_7 \end{array}\right\} + 3NaOH = \left.\begin{array}{r} CH_2OH \\ CHOH \\ CH_2OH \end{array}\right\} \begin{array}{l} + NaOOCC_{15}H_{31} \text{ (sodium palmate)} \\ + NaOOCC_{17}H_{33} \text{ (sodium oleate)} \\ + NaOOCC_3H_7 \text{ (sodium butyrate).} \end{array}$$

Relation of Butterfat and Lecithin. Fatlike substances called lipids exist in milk in much smaller quantities than the true fats. Lecithin is the lipid we are most concerned with in butterfats because (1) it is concentrated in cream to the extent that butterfat is concentrated; (2) it is a constituent of butter, although to a lesser extent in pasteurized-cream butter; (3) it is subject to chemical changes during butter storage (conditions favoring its breakdown are given in Chapter 11 under "Effect of Salt on Keeping Quality); (4) it interferes with butterfat tests of buttermilk; special tests have been devised because of this.

Other lipids are cephalin and cholesterol. The following arrangement shows a typical lecithin molecule:



Note the trimethyl grouping with the nitrogen. This is trimethylamine which may be separated from the lecithin molecule when conditions of cream handling and butter storage are favorable. It has a pronounced fishy flavor and odor.

Theory in Regard to Films Enveloping Fat Globules. The extreme minuteness of the fat globules in milk renders it almost impossible to determine by direct microscopical observation whether there is a membrane around each globule or not. Fleischmann and Lloyd assert that, so far as they were able to detect, there is no real membrane surrounding each globule.

The theory generally accepted in the past was that the film surrounding the fat globules was simply due to surface tension, or to the fact that the molecules of the fat have a greater attraction for themselves than they have for the molecules of the serum in which they are held in suspension. In suppost of this, two arguments are advanced.

1. The natural milk fat may be removed from milk and artificial fat substituted in its place. The resultant milk has characteristics similar to milk containing normal fat, that is, the emulsion which milk forms with the artificial fat is apparently like that formed with the natural fat.

2. If there were a special albuminous membrane around each fat globule, cream should contain a higher percentage of albuminoids than milk. This, Richmond maintains, is not so.

Dr. Storch concludes from extensive researches that there is a gelatinous membrane enveloping the fat globules. His conclusions are based mainly upon the first three reasons given below. The other facts mentioned also support his conclusions:

1. When milk has been stained with ammoniacal picrocarmine, and the cream washed with water until it is free from milk sugar, a stained layer is present around each globule.

2. Dr. Storch has succeeded in isolating this gelatinous substance from cream and butter. Owing to its existence in these two substances, he assumes that it is also present in milk.

3. When ether is added to milk, the fat globules dissolve with difficulty, unless some alkali is added to the milk first.

4. Bichamp maintains that when ether is added to milk the fat globules are enlarged, owing to the ether passing through the supposed membrane by the process of osmosis. He considers this fact sufficient to prove that there is a membrane encircling each globule.

5. Butter containing 85 to 86 per cent fat is asserted by Richmond to have the same consistency as cream containing about 72 per cent fat at the same temperature. The solidity of butter is due to the close proximity of the fat globules. Now, if cream with less fat has the same consistency as butter, the proximity of the fat globules must be equal to that of the butter; this would indicate that there is a membrane and that this membrane increases the size of the fat globules.

6. The fact that cream separated by centrifugal force is more easily churned than cream of the same richness separated by gravity methods would also be explained if the fat globules in milk had such a membrane surrounding them.

This membrane, or what is believed to be a membrane, Storch isolated and analyzed. He found it to consist of 94 per cent water and 6 per cent protein.

The reasons deducted by Storch are strong; and the behavior of cream and butter renders it probable that there is such a membrane enveloping each globule of fat.

Dornic and Daire in 1910 believed that the fat globule membrane consisted, in part at least, of lecithin. They reviewed Storch's work on the "Slimmenmembran."

Hatori in 1929 stated that a haptein membrane surrounding fat globules is a protein differing from any previously reported milk proteins.

Titus, Sommer, and Hart[2] in 1928 concluded that the protein surrounding fat globules is very clearly related to, if not identical with, casein. The sulphur, phosphorus, and tryptophane content of this protein agrees almost exactly with that of casein. The precipitation tests of this protein and casein show no distinction and point to their identity. Blood from rabbits immunized to either of the proteins was tested and precipitin tests obtained.

Palmer and Wiese [3] in 1933 stated that the material adsorbed on the surface of fat globules is a mixture of phospholipids and proteins and that the possibility of one of the components being that of a casein system is also excluded because of its low nitrogen content. The physical properties, percentage of nitrogen, sulphur, and phosphorus, do not correspond with those of any other milk protein. This fat-globule covering is largely removed during churning. The part it may play in churning remains to be determined.

Investigations of the nature of the fat-globule membrane are important for several reasons:

1. Relation to the time-temperature conditions of churning.
2. Fat losses in buttermilk.
3. Theories of churning:
   a. Foam theory.
   b. Inversion of phases.
   c. Electric charge on fat globules.
4. *p*H of cream.
5. Neutralization and heat treatment of cream.

Further studies are necessary to establish facts clearly. Many of the principles of buttermaking are still controlled on the basis of art and experience rather than on a purely technical basis.

PROTEINS OF MILK

Casein. More information on casein than other milk proteins is available because it is present in milk in comparatively larger quantities. Next to butterfat, it is commercially the most important component. It has a profound influence on the condition of emulsions as they exist in milk and cream. It is the substance which forms the frame work of coagulums of milk.

1. It is extremely important in cheese making.
2. It is chiefly responsible for the viscosity of evaporated milk.
3. It produces especially desirable results in the whipping ability of ice cream mixes and the body and texture of ice cream.
4. It facilitates the separation of water from other milk constituents in the digestion of milk in the stomach.
5. It is the basis of the innumerable commercial products made from casein. (See *Condensed Milk and Milk Powder,* fifth edition, 1935, by O. F. Hunziker, published by the author at La Grange, Illinois.)

Composition of Casein. Casein appears to be the most complete protein known. It has most of the amino acids known and contains rather liberal comparative amounts of amino acids regarded as essential to young growing life. Mixtures of proteins from varied sources may supply all essential amino acids. In no single protein do we have so complete a list and so perfect a balance for nutrition as in milk.

CASEIN AND GELATIN—AMINO ACID CONTENT COMPARED

Amino Acid	Casein	Gelatin	Amino Acid	Casein	Gelatin
1 glycine or glycocol...	+	+	12 methionine........	+	+
2 alanine..............	+	+	13 norvaline..........	+	?
3 valine...............	+	−	14 norleucine.........	+	−
4 leucine..............	+	+	15 an amino acid $C_{12}H_{26}N_2O_6$......	+	?
5 isoleucine............	+	+	16 HISTIDINE......	+0.9%	2.5%
6 phenylalanine........	+	+	17 TYROSINE.......	+4.5%	−
7 hydroxyproline.......	+	+	18 CYSTINE........	+0.07%	−
8 aspartic acid.........	+	+	19 PROLINE........	+8.7%	9.5%
9 glutamic acid........	+	+	20 LYSINE..........	+7.6%	+5.9%
10 hydroxyglutamic acid	+	+	21 TRYPTOPHANE..	+2.6%	−
11 arginine.............	+	+			

Capitals indicate amino acids known to be most necessary for growing animals.

Lysine and tryptophane are rather abundant in casein and frequently deficient in the proteins of cereals. Gelatin and zein contain no tryptophane. Tryptophane is essential to life, and these proteins cannot be used alone for any appreciable time without supplement from other sources. It has not been proved that any of the amino acids are unnecessary in complete nutrition. Some seem to be more essential than others.

Casein is largely in combination with calcium in milk. In fact, English authors refer to it as calcium caseinate or caseinogen. The combination of calcium and casein is in rather exact proportions in normal milk and is quite stable. It may be coagulated under steam pressure at about 275° F. Hours of boiling at atmospheric pressure may not cause visible coagulation. Casein may be destabilized in several ways and the degree of clumping of the casein molecules varies according to the treatment it receives. It is difficult to assign a single factor as the sole destabilizing agent. More frequently, there is a combination of factors responsible for results. For example, we may say that the development of acidity in milk causes a grouping of casein molecules and that finally a coagulum is formed. The presence of acid causes chemical changes to occur, and the resulting coagulum may be a result of secondary considerations, such as temperature, amount and kind of ions, etc.

$$\text{Calcium caseinate} + \text{lactic acid} = \text{calcium lactate} + \text{caseinogen}$$

Calcium lactate is soluble and ionizable and we therefore have free calcium ions which aid in the destabilization of casein.

Destabilization of casein is facilitated by the following factors:

1. Development of acid (souring) or addition of acids.
2. High and continued heat.
3. Presence of abnormal amounts of calcium or magnesium salts (natural or added).
4. Subnormal amounts of citrate or phosphate ions.
5. Freezing.
6. Homogenization—particularly at higher pressures.
7. Percentage of casein in milk.
8. Dilution with water.

Van Slyke and Price[4] give figures on the relation of fat and casein in milk as follows:

Ratio of Fat to Casein in Milk

Per Cent Fat	Per Cent Casein	Ratio Fat to Casein
3.0	2.1	1 to 0.70
3.5	2.3	1 to 0.66
4.0	2.5	1 to 0.62
4.5	2.6	1 to 0.60
5.0	2.9	1 to 0.59

(See Fig. 6 for additional data.)

Relation of Proportional Increase to Actual Increase in the Percentage of Casein in Milk as the Percentage of Fat Increases from 3.0 to 4.8 per cent (3.0 per cent Milk Is Basis of Calculations)

(Figures are from *Cheese*, by Van Slyke and Price.[4] Courtesy of Orange Judd Publishing Co.)

Per Cent Fat	Per Cent Casein	
	Proportionate	Actual
3.0	2.1	2.1
3.5	2.45	2.3
4.0	2.79	2.5
4.5	3.15	2.7
4.8	3.36	2.8+

These data are particularly important in yields of cheese from milk of various tests.

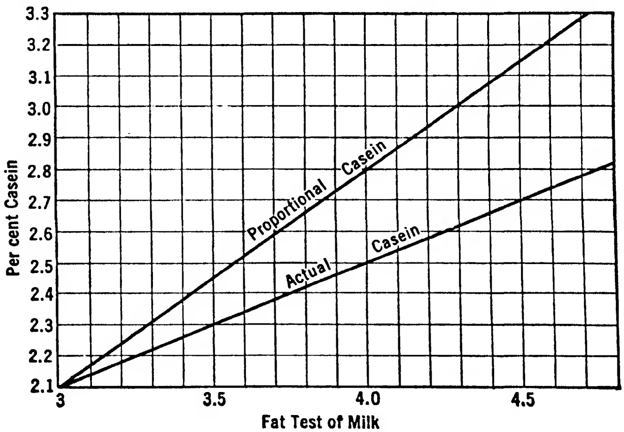


Fig. 6. The relation of the actual and proportional casein content of milk to its fat content.

Soft Curd Milk. Hill[5] has demonstrated that the character of curd produced from milk of individual cows varies in firmness or curd tension. This might lead to the thought that casein varies in its composition and properties. Experimental work by Doan and Welch[6] and others indicates that there are many factors other than the nature of casein involved. Some of these are:

1. Percentage of casein.
2. Salt balance.
3. Richness of milk.
4. Normality of milk.
5. Titratable acidity.

Doan and Welch indicate that the variation in casein content is the principal factor.

Albumin. Milk albumin has been found to be very similar to blood albumin although not identical with it. It appears, therefore, that there is at least a partial physiological synthesis of milk albu-

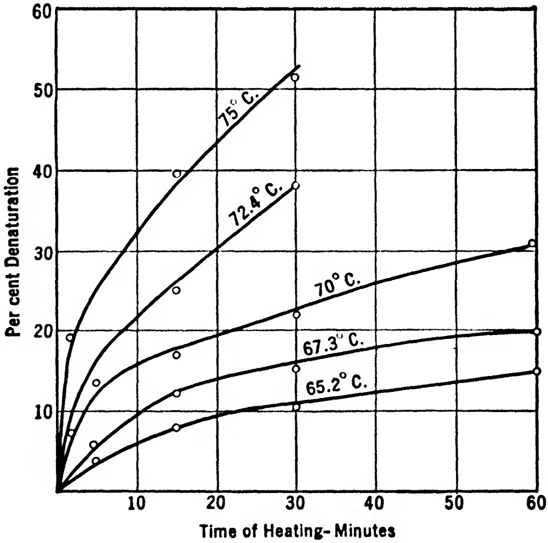


FIG. 7. Heat denaturation of albumin and globulin. After S. J. Rowland.[5]

min. It is not coagulable by acids or rennin but is precipitable by heat. Rowland[7] presents graphical data (Fig. 7) showing time-temperature relationships on the extent of denaturation of albumin and globulin. He states that the heat coagulation consists of two phases:

a. Denaturation—altering protein by heat flocculation.
b. Flocculation—rapid separation of protein in the presence of a suitable electrolyte.

The reaction is irreversible.

Milk albumin has not been important commercially but more recently it has gained importance as a constituent of whey powder. Whey powder is now used in considerable quantities as an ingredient in packaged fancy cheese and cheese spreads. It is a constituent of primost or whey cheese. It is a factor in processing evaporated milk. Abnormal amounts produce excessive heat coagulation.

Ash or Mineral Constituents of Milk. The minerals of milk are important from the standpoints of:

a. Nutritional value.
b. Electrolytic effects in processing dairy products.

Nearly one half the total mineral content of milk consists of calcium and phosphorus which are very essential in the proper development of skeleton and teeth. Other minerals are present in lesser amounts but may be relatively important in nutrition. The role played by some minerals is not definitely established, but the absence of some of them has been noted to cause nutritional disturbances.

The calcium and magnesium content and the citrate and phosphate content of milk assume considerable importance in the processing of dairy products. They influence the:

a. Coagulation of milk by rennin.
b. Heat coagulation of evaporated milk.
c. Reaction of milk to stability tests.
    1. Alcohol test.
    2. Phosphate test. (*J. Dairy Sci.*, Vol. 14, p. 93.)
d. Curd tension of milk.
e. Acidity of fresh milk.

Dahlberg and Marquardt [8] indicate a possible relationship of calcium ions to the creaming of market milk, and Henning and

Dahlberg [9] show that various amounts of sodium and calcium salts affect both size of fat clusters and the extent of clustering in ice cream mixes.

Vitamins. See Chapter 3, "Milk and Its Products as Foods."

Enzymes. Enzymes in milk and cream come from two sources:

a. Secreted in normal milk.
b. Developed by microorganisms.

Both classes are important from the standpoint of affecting the flavor of dairy products. In fresh products, microorganic enzymes may be present in such minute quantities as to be of no significance. Normal milk enzymes are present in milk in very small amounts, and their presence in normal fresh dairy products is without significance. When these products are stored, however, enzymes may cause serious quality defects. Such effects are noted in stored butter where fat may be split into fatty acids and glycerin. Butyric acid is responsible for a peculiar rancid flavor and odor. Other enzymes may break down the curd of butter and produce flavor defects.

The vat or holding method of pasteurization of cream as practiced in the past does not destroy all enzymes in cream. Controlled methods of flash pasteurization with temperatures of 180° F., or higher, are effective.

The standard conditions of vat pasteurization for many years have been 145° F. for 30 minutes. This partially inactivates some enzymes but does not destroy them. Although the deleterious effects of enzyme action in stored butter are not definitely established, present trends in pasteurization of cream are in the direction of higher temperatures. This may accomplish two purposes:

1. Further inactivation or destruction of enzymes.
2. Destruction of greater percentages of bacteria, yeasts, and molds.

The Land O'Lakes, Inc., now recommends 160° F. for 30 minutes for vat pasteurization of cream. Work by Guthrie, Scheib, and Stark [10] at Cornell also points to greater safety in butter-keeping quality if cream is heated at 165° F. and held for one-half hour. Various authorities indicate that enzymes are not inactivated unless heated to at least 158° F., and several of the more heat-resistant enzymes are not entirely inactivated at 175° F.

Pigments of Milk. The yellow color of butterfat is due largely to carotene. Xanthophylls in small amounts are usually associated with carotene in butterfat. Carotene is found in carrots and green feeds. This explains the fact that milk from cows on pasture has more carotene, is much more yellow, and is much richer in vitamin A. Carotene is the precursor of vitamin A.

In addition to the fat-soluble carotene, milk also contains lactochrome, more recently termed lactoflavin. The latter is water-soluble and gives whey its characteristic yellowish color. Recent investigations point to the association of lactoflavin with the vitamin B_2 (G) activity of milk. Palmer [11] refers to the vitamin G activity of lactoflavin. Day, Darby, and Langston [12] in 1936 reported that rats developed cataract when fed vitamin-B-deficient (all B vitamins) rations supplemented with extract of rice polishings. Litter mates of these rats fed the same diet, but with lactoflavin in place of extract of rice polishings, did not show cataract.

Lactochrome, lactoflavin, and more recently riboflavin, seem to refer to the same substance. The flavins are definite chemical compounds, and the flavin in milk appears to possess definite vitamin B_2 activity. The term lactochrome is to be avoided. It signifies nothing more than "milk-coloring substance."

Gases in Milk. Gases retained in milk are relatively unimportant. They are largely expelled during pasteurization. Van Slyke and Baker [13] report 10 per cent of carbon dioxide (by volume) in milk in the udder. This drops to 4 or 5 per cent immediately after milking and to about 3 per cent after a few hours. Milk heated to pasteurization temperature retains about 3 per cent of carbon dioxide as carbonic acid and sodium bicarbonate. Traces of oxygen, nitrogen, and some rare gases are also found in milk.

Germicidal Properties of Milk. A resumé of work and theory on the germicidal or bactericidal property of milk follows:

In 1890 Fokker in Germany found that sterilized milk soured much more promptly than raw milk when receiving like inoculations of milk-souring organisms.

In 1894 Hesse found cholera vibrios growing rapidly in boiled milk but not in raw milk.

In 1908 Rosenau and McCoy indicated that plate counts of bacteria are lower after raw milk stands a few hours and that agglutination or clumping of bacteria is the explanation.

In 1917 Klein [14] stated that a germicidal property of milk varies with the kind of organisms and the nature of the milk. He attributed germicidal power to the presence of antibodies in milk.

In 1930 Brew, Hastings, and Breed, replying to a survey made by *Hoard's Dairyman* (April 25, 1930), indicated that milk must be kept clean in milking and must be cooled with but little delay. Dependence upon a germicidal property is definitely inadvisable. Dr. Brew says, "Whether or not there are such substances has never been definitely demonstrated, but we are justified in saying that there is a period of readjustment which lasts for varying lengths of time.

Dr. Breed says, "It is highly desirable that morning's milk as well as night's milk be cooled immediately after milking if it is to be delivered directly to the consumer or if it is to be held any length of time before pasteurization."

Professor Hastings says, "The better the raw milk the better the pasteurized milk and hence, even in the case of milk to be pasteurized, I am certain the producer will do well to cool the milk, even the morning's milk."

Alice Evans, United States Department of Public Health,[15] advises that there is rather general agreement that any possible germicidal property milk may have is quite negligible and of temporary nature and cannot be relied upon in the handling of milk.

QUESTIONS

1. Give the average composition of milk as reported by the chemist.
2. Give a detailed list of all known milk constituents.
3. What two substances in milk are of greatest economical and industrial importance? Why?
4. Explain the relationship of fat saponification and the excessive or improper neutralization of cream.
5. Why are we concerned about fatlike substances (lecithin) in dairy products?
6. Why is casein very valuable from these considerations:
   a. In nutrition?
   b. In cheese making?

7. Explain the significance of the minerals of milk:
   a. In nutrition.
   b. In relation to salt balance and dairy products processing.
8. From what two sources do enzymes in cream and butter come?
9. Are these enzymes heat labile?
10. Discuss the pigments of milk as relating to:
   a. Their solubility.
   b. Significance in buttermaking.
   c. Relation to vitamins.
11. What is meant by the germicidal property of milk? How would you proceed to demonstrate the existence or absence of such factors? State its commercial significance.

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CHAPTER 3

MILK AND ITS PRODUCTS AS FOODS

HIGH VALUE OF MILK FAT

There are two methods for the classification of foodstuffs for animals and man, both of which will be considered briefly in this chapter, with special reference to milk and its constituents—particularly milk fat—as not only valuable but also indispensable parts of the dietary.

The older method may be spoken of as the *chemical method.* It considers and classifies foods largely in accordance with their content of water, protein, carbohydrates, fats, and mineral matter. This, in itself, is quite incomplete, as will be shown later.

The newer method, which is known as the *biological method,* is based upon a study of the properties and values of the different foodstuffs, through feeding them and noting their effect upon growth, health and reproduction. This method, though comparatively new, has made very rapid strides and has established the fact that food constituents which come under the same chemical head are by no means either alike or of equal nutritive value.

There is neither the hope nor the expectation that the biological will supersede the chemical classification of foods and foodstuffs, in the sense of dispensing with the aid of chemistry. The true, unbiased student of the problems of nutrition recognizes two things: first, that the chemical method has rendered and will continue to render a very large service and, second, that in itself it is too mechanical and incomplete.

In the last analysis, the biological classification of foodstuffs must prevail, but this does not mean that it and chemistry are at variance with each other. Rather it means that there must be a merging of the chemical into the larger or biological method, and that in future a larger, fuller, more intelligent and less mechanical use will be made of chemistry as an aid in determining the values of the different foodstuffs and how they may best be combined with each other in the compounding of more economical and complete rations and diets on which animals and man will grow and thrive.

CHEMICAL CLASSIFICATION OF MILK AND ITS PRODUCTS AS FOODS

From the chemical standpoint, the constituents of the food material consumed by animals and man are classified under the heads of water, combustible matter and ash, mineral matter or salts—all three terms being applied to the last class.

The combustible matter includes the carbohydrates (such as starches and sugars), the fats (such as milk fat, olive oil and other plant oils, and meat fat), and the proteins (such as the curd of milk, the gluten of wheat, and the muscle fiber of lean meat).

The carbohydrates and fats are largely burned to supply heat and energy, and are also used for the making of fat in the body and in milk.

The proteins are used, in part, for the same purposes as the carbohydrates and fats, but their distinct function, which these latter cannot perform, is that of supplying material for the making of muscle and other body tissue.

The ash or mineral matter is used for making bone, regulating the heart action and the elasticity of the muscles in general, and preventing acidity of the blood and tissues.

Under the older classification of foods we find that milk and its products are given a very high place because of their high content of the different foodstuffs or constituents and their high degree of digestibility. A quart of average milk is considered by such high authorities as Sherman of Columbia University to be approximately equal in food value to a pound of steak, or eight or nine eggs. He is here referring chiefly to their heat and energy value and high degree of digestibility.

American cheese (a Cheddar cheese) may be regarded, in a very large sense, as a concentrated form of milk because it contains most of the milk constituents, excepting the sugar. It has about twice the food value of average meat. On this point Sherman says, "Generally speaking, cheese sells at no higher price than the ordinary cuts of meat. It is a fair general estimate that a given amount of money spent for American cheese will buy about twice as much food value as it would if spent for meat."

Altogether, apart from a distinctive and most important function which will be considered later, butter has a very high heat and energy value—a pound being equal to about five quarts of average milk. It is by no means merely a relish, as it has been considered by many in the past.

We cannot afford the space to discuss here the food values of the various other milk products, such as cream, ice cream, and condensed milk. It will suffice to say that in food value cream occupies an intermediate position between milk and butter, combining the features of both.

BIOLOGICAL CLASSIFICATION OF FOODS

The High Value of Milk and Milk Fat under This Classification. The biological study of foods—based upon observations as to the influence of various foodstuffs upon the growth and thrift of animals—has revolutionized our ideas with regard to problems of nutrition and has established the fact that the biological classification of foods is the true one. In doing so it has shown that milk and milk fat have values as foods which, a few years ago, were quite unknown and as yet have not been determined chemically—or at least have been determined only in part.

It was but natural that students of the problems of nutrition should give their attention to milk. Knowing that the young grow and thrive on a diet composed exclusively of milk, they realized that this food must contain nutritive material of an exceptionally high order.

Proteins. The proteins of plants differ from those of animals and of each other. Animals do not take the proteins of their foods, whether of plant or animal origin, and use them as such, without any change. In the processes of digestion and assimilation, animals break proteins up into the simpler substances, amino acids, and from these build up the proteins of the muscle and other tissues of the body.

There are eighteen amino acids that are considered in nutrition problems. The protein of wheat (gluten) is able to supply only a limited number of these in sufficient quantity, and some not at all.

The proteins of the corn kernel (zein, etc.) are able to supply others, and so on with the proteins of the different foods; but none of these is a complete protein food for the animal body. The chief protein of milk (casein), however, is an exception, being a very complete and well-balanced protein which is able to supply the different amino acids in sufficient quantities and right proportions to build up muscle and other protein tissue of the body. Thus we would say that milk furnishes protein of a quality quite superior to that of almost any other food. This we see exemplified in the fact that the young animal lives, grows, and thrives on milk alone.

Ash or Mineral Matter. In the ash or mineral matter of the food there must be a sufficiency of such elements as sodium, potassium, calcium, magnesium, iron, etc., in the form of inorganic salts. These perform very important functions. Each has its work to do, and they are not interchangeable.

In a mixed diet, there is usually, but not always, a sufficiency of the compounds of the different elements mentioned. We quote Sherman upon this point:

> There must also be maintained in the body a proper balance between sodium and calcium (the metal of lime). For example, the rhythmical contraction and relaxation of heart muscle, which constitutes the normal beating of the heart, is dependent upon this muscle being bathed by a fluid containing the proper concentration and quantitative proportions of sodium and calcium. Calcium is not always sufficiently abundant even when the food is freely chosen; hence the richness of a food in calcium is a factor affecting its value.[1]

McCollum and Simmonds found, as a result of their experiments, "that the deficiency in mineral elements in wheat and other seeds is limited to three elements, calcium, sodium and chlorine."[2]

The ash of milk is present in liberal quantity, is of high quality and well balanced, and is rich in its lime content as a source of calcium. There is more lime in a pint of milk than in a pint of limewater.

Two Very Essential Vitamins Found in Milk Fat.* As early as 1906, Hopkins of Cambridge (England) showed con-

* Vitamin A has now (1939) been synthesized and its chemical composition established. Vitamin B has been separated into six related substances which have not been synthesized.

clusively that on an apparently complete food made up of purified proteins, ordinary fats, carbohydrates, and salts young rats would not grow, but that when a very small amount of milk was used—enough to make up about 4 per cent of the dry matter of the food—growth became entirely satisfactory. This led him to conclude that there were present in milk unidentified food substances which he termed "accessory" articles of the diet. These would be what McCollum terms the "fat-soluble A," which is found in milk fat but not to any appreciable extent in the ordinary fats, and the "water-soluble B," which is more generally distributed in foods, particularly in diets of mixed foods.

Bloch, a Danish physician, observed about forty cases of severe eye trouble, accompanied by ulceration, in children near Copenhagen. This would, without doubt, have ended in blindness. These children had been receiving skim milk, instead of whole milk, in their diet, and were practically deprived of milk fat in their food. When the younger of them were given mother's milk and the older either cow's milk or cod liver oil, they responded and recovered. He attributed the trouble to the lack of fat in their foods; but it will be noted that in all cases the real cause of recovery was the feeding of fats containing the fat-soluble substance which is present in the fats of milk, the yolk of egg, the liver and other body glands, and the leaves of plants, particularly such plants as alfalfa and the clovers.

Mori found 1400 cases of similar eye trouble amongst children in Japan. These children responded to the feeding of chicken livers.

It has been found both by McCollum and Davis, and by Osborne and Mendel, that milk fat contains a fatlike or fat-soluble substance whose presence or absence in a food, otherwise entirely satisfactory, means the difference between growth and no growth in the young. In addition to this, both these pairs of investigators found that, deprived of such a fat as milk fat, the young animal would develop a disease of the eyes which would ultimately cause blindness and, if persisted in, would end in death; but that if this fat were restored in time the eyes would become normal again, and the young animal would return to its former health and vigor and resume normal growth.

It would be unfair to credit any one man, or set of men collaborating with each other, with the discoveries that have been made during the past 15 or 20 years—and particularly within more recent years—through the biological study of foods. The list of investigators is rather a formidable one and, as has already been indicated, includes students of the subject in America, in Europe, and even so far away as Japan. Without doubt the best known of these in America is Dr. E. V. McCollum, whose extensive and most valuable articles have appeared in *Hoard's Dairyman* and other farm and scientific journals and who has issued a valuable book on the subject, *The Newer Knowledge of Nutrition.* In this book he outlines the investigations conducted by him and his co-workers—Babcock, Hart, Davis, Steinbeck, Humphrey, Parsons, Funk, Kennedy, Simmonds, and Pitz—and also familiarizes us with the work of many other investigators.

As McCollum intimates, in order to secure reliable and exact data it was necessary to feed purified foodstuffs (purified protein, carbohydrates, fats, and mineral salts), and in order to do this and secure sufficient data within a reasonable time it was necessary to experiment with small animals. For these reasons, the experiments were conducted mostly with young rats, although like results were also obtained with other animals, including cattle and pigs. *Accumulated data, from a variety of sources, show that the results secured are equally applicable to the different animals, including man.*

In one of the earlier experiments with rats, McCollum and Davis fed a diet composed of purified protein (casein) to the extent of 18 per cent, lactose or milk sugar, 20 per cent (supposed to be pure), about 5 per cent of some fat, together with a salt mixture made up in imitation of the mineral matter of milk, and the remainder of starch to make up 100 per cent. The results of this experiment were that, when the fat used was milk fat, growth could be secured; but, when milk fat was replaced by such fats as lard, olive oil, or other vegetable oils, there was no growth. When the fat of yolk of egg was used instead of milk fat it also induced growth. These experiments established the fact that fats from different sources are by no means equal in dietary value.

After this experiment a more elaborate experiment was planned and carried out by McCollum and Davis. It will be noted that the diet of purified foodstuffs, which proved a satisfactory one, was made up of purified milk constituents. McCollum and Davis next tried the wheat seed or kernel. They reasoned that it contained protein, carbohydrates, and mineral salts and fats or oil, and that if these were mostly equal in quality to those of milk the only foodstuff that might have to be added would be a growth-promoting fat. They first fed wheat alone and then experimented with it, using one dietary factor at a time. The following table shows the different combinations in which wheat was fed, with results obtained:

1. Wheat alone	No growth, short life.
2. Wheat, plus purified protein	No growth, short life.
3. Wheat plus a salt mixture which gave it a mineral content, similar to that of milk	Very little growth.
4. Wheat plus a growth-promoting fat (milk fat)	No growth.
5. Wheat, plus the protein, plus the salt mixture.	Good growth for a time, few or no young, short life.
6. Wheat, plus protein, plus a growth-promoting fat (milk fat)	No growth, short life.
7. Wheat, plus the salt mixture, plus the growth-promoting fat (milk fat)	Fair growth for a time, few or no young, short life.
8. Wheat, plus protein, plus the salt mixture, plus a growth-promoting fat (milk fat)	Good growth, normal number of young, good success in rearing young; life approximately the normal span.

This series of experiments again proves the necessity of a growth-promoting fat. But it does more than this; it shows that the proteins and mineral matter from different sources are not of equal value, those of milk being altogether superior in this respect to those of such a food as wheat. Other experiments proved that the seeds of other cereals are, like wheat, quite incomplete in themselves as diets.

In following up this investigation it was found that, when polished rice was substituted for wheat in No. 8 of the series of experiments just outlined, the diet failed utterly to induce growth. This was puzzling. The investigators had been able to induce successful growth through feeding a diet composed of purified protein (casein), milk sugar (supposedly pure), salts in imitation of the mineral matter of milk, and milk fat. They could see no reason why the polished rice, supplemented by purified protein, suitable salts, and milk fat, should not be a complete food. This was cleared up subsequently by establishing the fact that the milk sugar used in the former of these two experiments and the germ or chit of the cereal seeds, which had been rubbed off the rice, contain a water-soluble substance essential for growth, health, and vigor.

The conclusions finally reached were, first, that among the food substances (protein, carbohydrates, and ash or mineral matter) coming from different sources there is a marked difference in quality, and that those from milk are of a very high order; and, second, that there are two substances indispensable to growth and health, the one found in milk fat, the fat of yolk of egg and some of the glandular fats, which McCollum and Kennedy subsequently designated "fat-soluble A," and a second substance soluble in water, which they called "water-soluble B." The absence of the fat-soluble A not only prevents growth but also causes a serious eye trouble which, if not corrected in time, will end in blindness and death. We have already illustrated this point. The absence of the water-soluble B also prevents growth and causes serious physiological disturbances resulting in a form of paralysis, beriberi, which is quite prevalent where such foods as polished rice and bolted flour form the main articles of diet.

But this water-soluble B is present in most ordinary food substances, and particularly in a mixed diet, whereas the sources of the fat-soluble A are quite limited, the fat of milk, in the form of milk and butter, being the chief of these sources.

In support of what has been said, the utterances of some of our leading physiologists and students of nutrition may be quoted.

Dr. H. C. Sherman, Professor of Food Chemistry, Columbia University:

> Especially in the feeding of children should milk be used freely, because of its many advantages as a tissue-building and growth-promoting food. A quart of milk a day for every child is a good rule easy to remember.[1]

United States Food Administration:

> Milk is one of the most important food sources the human race possesses. For the proper nourishment of the child it is absolutely indispensable and its use should be kept up in the diet as long as possible. Not only does it contain all the essen-

tial food elements in the most available form for ready digestion, but the recent scientific discoveries show it to be especially rich in certain peculiar properties that alone render growth possible. This essential quality makes it also of special value in the sick room. In hospitals it has also been shown that the wounded recover more rapidly when they have milk.

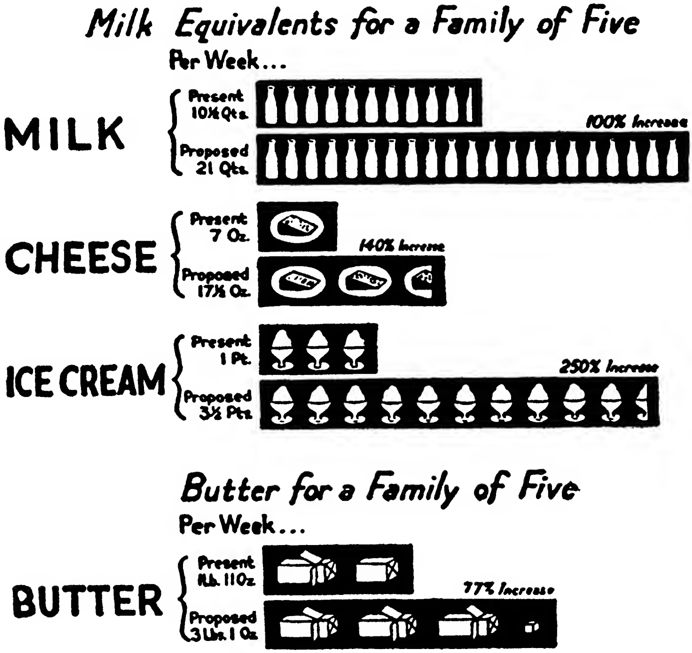


FIG. 8. The amount of dairy products now consumed compared to the amounts recommended by recognized food authorities. Courtesy of the National Dairy Council.

For the purpose of stimulating growth, and especially in children, butter-fat and other constituents of milk have no substitutes.

Dr. E. V. McCollum, Johns Hopkins University:

I have come to the conclusion, after carefully analyzing the probable effectiveness of the combinations of foods employed in human nutrition, that the efficiency of a people can be predicted with a fair degree of accuracy from a knowledge of the degree to which they consume dairy products. Probably the use of meat and of milk and its products will, in nearly all cases, run more or less nearly parallel, and I venture to assert that it is the milk and butter and cheese, and not the meat which has the

> good influence in the promotion of the virile qualities of the people.
>
> Milk is worth much more than its energy value or than its protein content would indicate. It is the great factor of safety in making up the deficiencies of the grains which form and must continue to form the principal source of energy in our diet.
>
> It seems probable that the only unidentified substance which is physiologically indispensable, which is not sufficiently abundant in the diets employed by the people of the United States and Europe where there are used insufficient amounts of milk, butter, cream, eggs and the leafy vegetables, is the fat-soluble A.
>
> I wish to again emphasize the fact that there is no way to supply this dietary factor (fat-soluble A) in the food of children except in the form of milk-fat, and milk is therefore an indispensable food for the young.[2]

Attention should be called to one other point. It has been suggested by some that possibly pasteurization of milk or cream destroys the growth-promoting qualities of the fat-soluble A in the fat. Osbourne and Mendel found that passing live steam through milk fat for two hours did not affect it, and McCollum and Davis found that it was not affected by being heated to the boiling point of water. This should be satisfactory evidence that pasteurization of milk or cream in no way affects the growth-promoting qualities of the milk fat.

FOOD VALUE OF DAIRY PRODUCTS

Butter As a Food. The value of butterfat as a food has been proved beyond question. It is equivalent in energy value to other fats and oils. It is superior in vitamins A and D. It is superior to many other fats in digestibility and especially so for the young. It is unequaled in palatability, as a spread for bread, and for general use in cooking.

Milk As a Food. Milk as a food cannot be eliminated from the diet of children. All too frequently we see the effects of malnutrition in children because of reduced amounts of milk. If malnutrition does not appear in the form of rickets we may observe lack of vigor and general good health. We see children that are afflicted with common "colds" throughout the winter season. Their growth is retarded. A liberal use of milk is a definite safeguard. Many city schools now have a milk fund supplied largely by charity, and children are furnished free milk. Increased health and better school work have been revealed in the records of many children.

Proteins of Milk. The food value of milk fat has been discussed. The proteins of milk, chiefly casein and albumin, have rather outstanding nutritional value. Casein contains all the essential amino acids. It contains liberal amounts of tryptophane and lysine. These are often lacking in plant proteins. The casein of milk, therefore, is an invaluable supplement to proteins from other sources. Indeed, some of the beneficial effects of milk in the diet may be attributable to the fact that casein is so complete and well balanced with reference to its amino-acid content.

Milk Sugar or Lactose. Lactose is found only in milk. It has peculiar nutritional and health-promoting properties. Our knowledge of the functions of lactose in relation to health is not extensive. Lactose is less fermentable in the alimentary tract and therefore more soothing. It aids in promoting in the intestines certain types of bacterial growth which inhibit putrefaction.

Whittier, Cary, and Ellis [3] state that rats live longer on lactose than on sucrose. Kleine, Keenan, Elevhjem, and Hart [4] report that lactose produces a more acid condition in the intestines and therein lies part of its prophylactic properties in relieving coccidiosis in chickens. They found lactose to be a definite aid in calcium absorption in chicks and, up to 20 per cent levels, it aided in proportion to the amount of lactose fed. Maltose or citric acid failed to facilitate calcium absorption. Ultraviolet irradiation of chicks increased acidity in the upper intestinal tract, whereas lactose, either alone or with vitamin D, increased acidity in the entire intestinal tract.

In the California State Penitentiary a group of men past middle life were fed 1 to 2 ounces of lactose in addition to their regular diet. This group had blood pressures approaching the 200 mark. After 6 weeks of the lactose diet their blood pressure was reduced to near normal (140). The lactose was discontinued, and in another 6 weeks the blood pressure of these men gradually climbed back to near its original high point.

Minerals of Milk. Over one-half the total mineral content of milk is calcium and phosphorus. Because they are particularly essential in bone and tooth development, we again see the particular need of milk for children. Cheese is a concentrated form of milk and is an excellent source of minerals. The fat of milk contains vitamin D, which is essential in the retention and use of these minerals in body building. Thus we have revealed to us the wonderful provision of nature in making milk a complete food and of insuring its utilization by such safeguards as vitamin D.

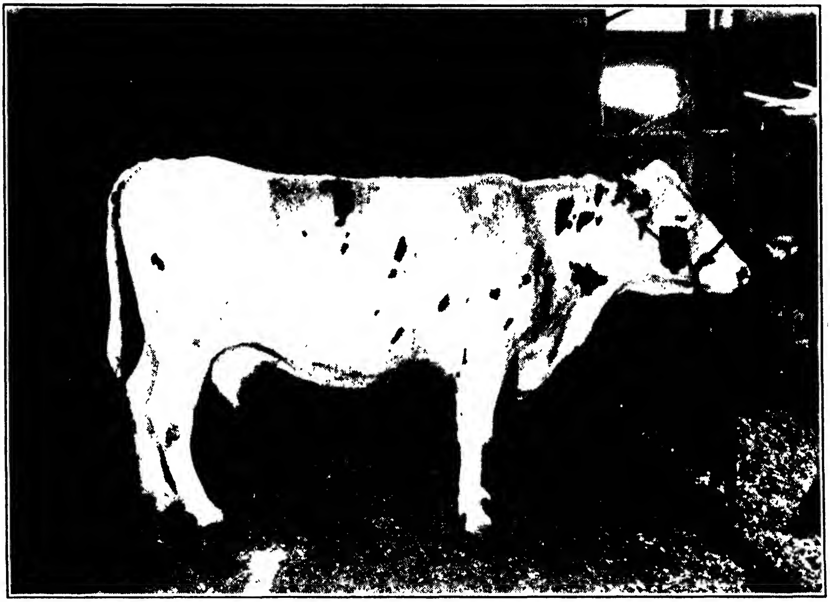


FIG. 9. Vitamin-D study. Holstein cow (No. 1-E), 7 years old. On vitamin-D deficient ration for 15 months. Picture taken one week before calving on April 4, 1937. She was dry during gestation period. Showed no signs of rickets until about two months before calving, when she was slightly "off feed" and her blood tests showed lowered calcium and phosphorus. No physical signs were observed. Courtesy of the South Dakota Experiment Station.

Vitamin-D Milk. During recent years means have been provided for increasing the vitamin-D content of market milk. Impetus for this development was supplied by:

a. Discoveries by Dr. Steenbock of Wisconsin University that foods could be irradiated with ultraviolet light and their vitamin-D potency greatly increased.

b. Because the natural vitamin-D content of milk varies rather widely and is sometimes insufficient in winter. The cow's ration is known to cause these variations.[5]

The medical profession has recognized the need for increased vitamin D in the diet and has approved the practice of increasing the vitamin-D potency of market milk. This is accomplished in three ways:

1. Feeding irradiated yeast to cows.
2. Adding vitamin-D concentrates to milk.
   a. Obtained from fish-liver oils and patented by Columbia University (Zuker process).
   b. Addition of irradiated ergosterol (Steenbock method).

FIG. 10. Vitamin-D study. Pictures of calf dropped by Holstein cow No. 1-E. Note the physical evidence of lack of vitamin D in the mother's ration. Courtesy of the South Dakota Experiment Station.

3. Irradiation of milk in thin films and exposed under controlled time and light intensity. Carbon-arc lamps produce ultra-violet light rays. These are effective in producing increased vitamin-D content.

The vitamin-D potency of milk is tested, thus certifying to the consumer that the milk contains approved amounts. Periodically, samples of vitamin-D milk must be sent to the laboratory where assays are made. All such assays are made by the Wisconsin Research Foundation, Madison, Wisconsin, except for milk plants using the Zuker process, which is controlled by Columbia University in New York City. The right to use these methods is sold by the authorities indicated. Usually a specified royalty charge of a fraction of one cent per quart of milk treated is made.

Regarding milk, Dr. James A. Tobey says:

Milk is universally recognized as possessing unique values in human nutrition. This lacteal secretion, which is the original food of the race, furnishes an exceptionally well-balanced combination of easily assimilated fat, carbohydrate, protein, minerals, fluid, and vitamins, all of which are essential to the growth and proper nourishment of man. No other single food displays so many desirable nutritive qualities, and there is, consequently, no substitute for milk in the human diet.

Milk undoubtedly possesses still other nutritional substances as yet undetected, since milk itself has been shown to give better results in the diet than a mixture of its components, as separated out by the chemist. Milk is, in fact, such a remarkable all-round food that every one who contemplates its many virtues will agree with a remark of the late Thomas A. Edison, who lived largely on milk. "The Almighty knew His business when He apportioned milk. He is the best chemist we have."

FIG. 11. Results of lack of vitamin-D. Wis. Research Bull. 115, 1933, Rupel, Bohstedt, and Hart.

In order to facilitate understanding of the discussion of vitamins the outline on page 38 has been prepared.

The factor or factors composing vitamin G are undergoing much study. American investigators are favoring the English classification of G as one of the B vitamins. English authors describe the B group of vitamins as follows:

B_1 heat-labile, antineuritic, antiberiberi.

B_2 heat-stable, antipellagra, antidermatitis for rats.

B_3 heat-labile, required for pigeons.

Vitamin Outline

	A	B	C	D	E	G
Sources	butter cream milk cheese egg yolk liver fish-liver oils vegetables, especially green vegetables and carrots	dairy products cereals—particularly in germ nuts wheat and rice hulls	dairy products citrous fruits tomatoes other vegetables other fruits	butter other milk fat products egg yolk vitamin-D milk other irradiated foods sunlight fish-liver oils	milk egg yolk meat cereals germ and germ oils vegetables (green) vegetable oils	milk whey and yeast liver, kidney, spleen citrous fruits vegetables greens eggs fish
Relation to Health	promotes growth health appetite digestion healthy offspring inhibits respiratory diseases lack of vigor	promotes appetite digestion bowel regularity healthy offspring inhibits beriberi polyneuritis	promotes tooth formation skeletal development general health inhibits scurvy decalcification loss of appetite fatigue	promotes utilization of calcium and phosphorus in skeleton formation good teeth improved metabolism inhibits rickets nervous ailments	promotes fertility reproduction normal gestation inhibits sterility degeneration of reproductive organs fetal death	promotes general health probably acts in conjunction with other dietary factors inhibits pellagra (skin disease) tongue and mouth soreness diarrhea general depression
Common Identification	fat-soluble A, for growth and health resistance to disease	water-soluble B, for appetite, digestion, elimination	water-soluble C, antiscorbutic vitamin	fat-soluble D, antirachitic vitamin	fat-soluble E, antisterility vitamin	water-soluble G, antipellagra vitamin

B_4 heat and alkali labile.
B_5 required for pigeons.

A vitamin of this group, indicated as B_6, appears to be associated with B_2. Both appear to be associated with flavins. Lactoflavin of milk has nutritional properties which seem to be associated with both B_2 and B_6. The term riboflavin instead of lactoflavin is now favored by a number of authorities.

Extensive experimental work is in progress on this group of vitamins. Definite names and descriptions are lacking. It should be noted that some of these factors are indicated as essential for rats, pigeons, etc. Their dietary properties for other species is uncertain or unknown.

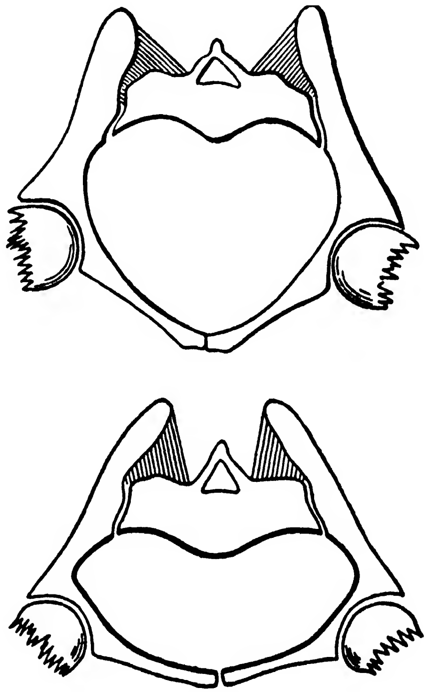


FIG. 12. The human pelvis; how rickets is manifest in babyhood and in later years. Normal pelvis (top) and deformed pelvis (below). The relation to childbirth is apparent. Lack of vitmain-D causes skeletal deformations. Courtesy of Standard Brands Inc.

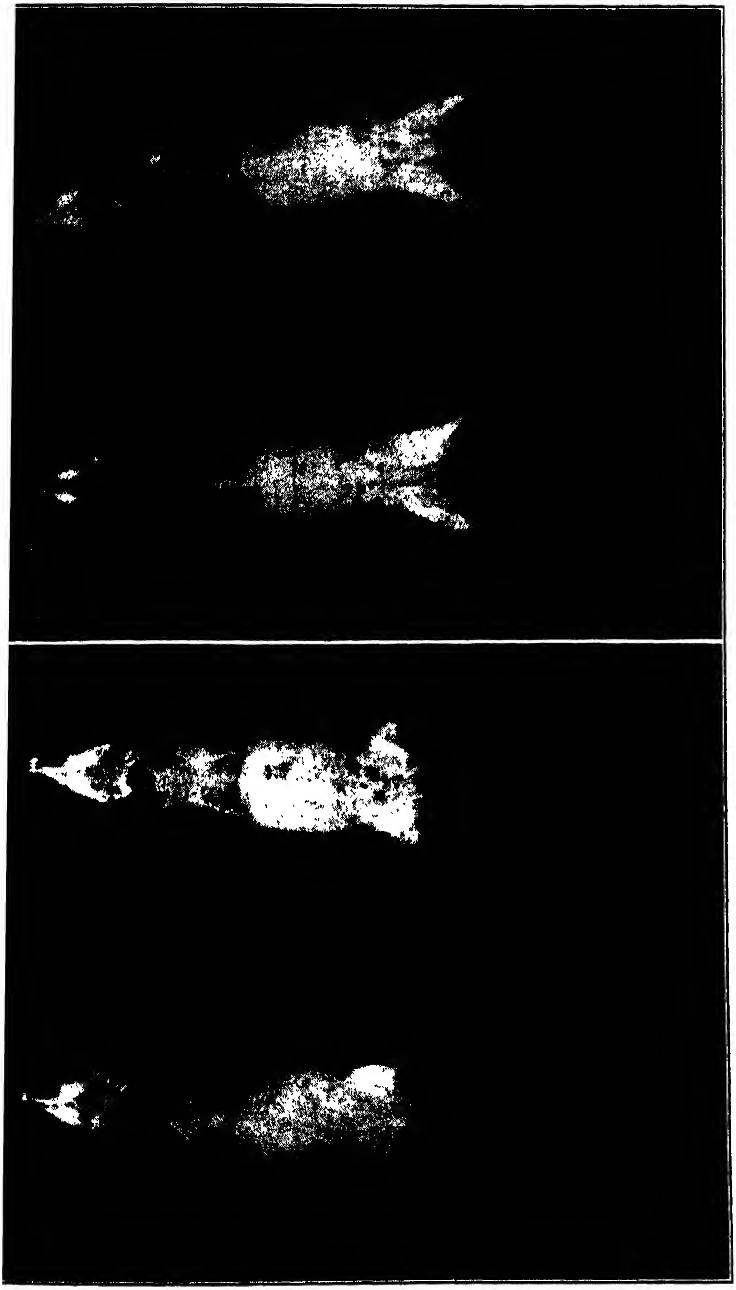
Figure 8 demonstrates quite clearly the need for greater use of dairy products. Increased consumption will depend upon several factors, among which should be listed (*a*) the price, (*b*) the quality, (*c*) the consumer's ability to buy, (*d*) the kind, amount, and quality of advertising, (*e*) education of children and parents, etc.

Figures 9 to 14, inclusive, show the ill effects of the lack of vitamin in nutrition. Not only is the individual adversely affected but progeny may be very seriously handicapped. Dairy products are an excellent source of both energy and vitamins. Their place in the diet has been clearly indicated by food authorities.

FIG. 13. Vitamin-D studies. Three rats at left received rickets-producing ration plus 12 cc. of cow's milk daily. Small rat (right) received rickets-producing ration and *no milk*. S. Dakota Bull. 296, 1935, T. M. Olson and G. C. Wallis.

QUESTIONS

1. Name two general methods of classifying foods on the basis of nutritional value. Compare them.
2. Name four general groups of food substances.
3. What nations supplied information on vitamins at an early date (1906)?
4. Who are E. V. McCollum and H. C. Sherman?
5. Compare winter and summer feeds in their effect on the vitamin content of butterfat.
6. List vitamins A to G, and state some sources and physiological functions of each.
7. What two vitamins does butter contain in abundance?
8. How does butter excel most other fats and oils from the standpoints of palatability and digestibility?
9. Why are the minerals of milk valuable?
10. What causes variations in the vitamin-D potency of natural milk?
11. Name three ways of increasing the vitamin-D content above that of normal milk.
12. What checks are made on milk plants in their sales of vitamin-D milk?



Vitamin-D Studies. S. Dakota Bull. 319, 1938, T. M. Olson and G. G. Wallis.

FIG. 14. "W-10." X-ray picture of two rats of the group which received 10 per cent of winter-produced milk fat in addition to the basal ration (Steenbock 2965). The Steenbock ration lacks vitamin-D.

FIG. 14. "S-10." X-ray picture of two rats from the group which received 10 per cent of summer-produced milk fat. Note the broad, well-formed chests and superior skeletal development. All bones appear denser and stronger.

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CHAPTER 4

VARIATION OF FAT IN MILK AND CREAM

As the variations in the percentage of fat in milk and cream are due to such widely different causes, it has been found expedient to divide this chapter into two parts.

PART I

VARIATION OF FAT IN MILK

The percentage of fat in normal milk varies a great deal more than the percentage of any of the other constituents. Dr. Richmond reports that the fat of milk may go as low as 1.04 per cent and as high as 12.52 per cent. Such extreme variations are, of course, abnormal. The fat content seldom falls below 2½ per cent or rises above 7 per cent. The fat content of milk from a whole herd of cows varies only within comparatively narrow limits. The following are the chief factors which cause the fat content of milk to vary:

1. Individuality of cows.
2. Breed of cows.
3. Time between milkings.
4. Manner of milking.
5. Whether the milk is fore or after milk.
6. Age of cow.
7. Advance in lactation.
8. Feed of cows.
9. Environment.
10. Condition of cow.

Individuality. Whether a cow will produce milk with a high or low fat content depends upon something that is inherent in the individual animal. Cows in the same herd, under the same conditions as to care, feeding, etc., will produce milk that differs widely in this respect. The secretory organs of the mammary gland are the large controlling factors, and these can be changed only by selective breeding. Even in the same breed we find animals that differ very widely, as the table below compiled from complete records by Eckles will indicate. These are average yearly tests for the animals testing highest and lowest in each breed.

Breed	Number of Cows	Highest Per Cent of Fat	Lowest Per Cent of Fat
Jersey	76	7.00	4.47
Shorthorn	25	4.31	3.59
Holstein	40	3.81	2.60

Breed of Cows. The different breeds of dairy cattle have their distinctive "breed characteristics," the most important of which are the quantity of milk they produce and its richness in butterfat.

The Channel Island breeds—Jersey and Guernsey—are noted for the high fat content of their milk; the milking strain of Shorthorns and Ayrshire breed produce a milk of medium richness; whereas the Holstein produces a milk somewhat lower in fat content.

For all the breeds, excepting the Milking Shorthorn, the table which follows, giving the *average* production and composition of the milk of the different breeds, is based upon Bulletin 156 of the Bureau of Animal Husbandry of the U. S. Department of Agriculture, which summarizes and digests the published reports of all the American experiment stations upon this subject.

Time between Milkings. Where cows are milked twice a day—the common practice in the United States and Canada—the difference in the percentage of fat in the two milkings is quite marked, if the intervals are very unequal. On the other hand, if the intervals are equal, or nearly so, the difference is not great. Experiments made by Ingle bring these points out quite clearly. Five cows were milked at 6 A.M and 3 P.M. during a period of 3 weeks. The average fat content of the evening's milk was 4.26 per cent, whereas that of the morning's milk was 2.8 per cent. After this, for 4 weeks, Average Composition of the Milk of Different Breeds

Breed	Yearly Milk Yield, Pounds	Per Cent of Fat	Pounds of Fat	Per Cent of Total Solids
Jersey	5508	5.14	283	14.9
Guernsey	5509	4.98	274	14.2
Ayrshire	6533	3.85	252	12.9
Holstein	8699	3.45	300	12.3
Milking Shorthorn	5500	4.00	220	13.0

the cows were milked at 5.30 A.M. and 5 P.M., and the average evening and morning tests were 3.80 per cent and 3.18 per cent, respectively. Even here there was a difference of an hour in the length of the two intervals, which would account, largely, for the difference in test. It is claimed, however, that with equal intervals the evening's milk will test slightly higher than the morning's milk. This is attributed to greater activity of the fat-secreting cells when the cows themselves are more active.

Milking three times a day, as is the custom in Denmark, increases, to some extent, both the quantity of milk produced and the percentage of fat in it. But the increase is not sufficiently marked to induce the average farmer in America to adopt this practice, unless the cow is an exceptionally large producer.

Manner of Milking. Milking should be done in such a manner as to induce the cow to be sympathetic toward the milker. Hand milking should be performed quickly, but not roughly or in a way that will excite the animal or create discomfort. The hand should close regularly and quickly from above downward, in such a way as to extract the milk quickly and efficiently. The finger ends should not press into the teats uncomfortably, nor should the nails come into contact with the teat to the extent of irritating it. As will be seen in dealing with fore and after milk, the milking must be done thoroughly since the strippings are very rich in fat content.

There is a marked difference between milkers. On this point we quote from Decker: "By looking over the milking records of the University of Wisconsin, it was possible to pick out the cows milked by a certain milker, for he could (or rather did) invariably get more and richer milk from the same cows than when the cows were milked by other men."

Fore and After Milk. The first milk drawn from a cow is very low in fat content, containing just a few tenths of a percentage

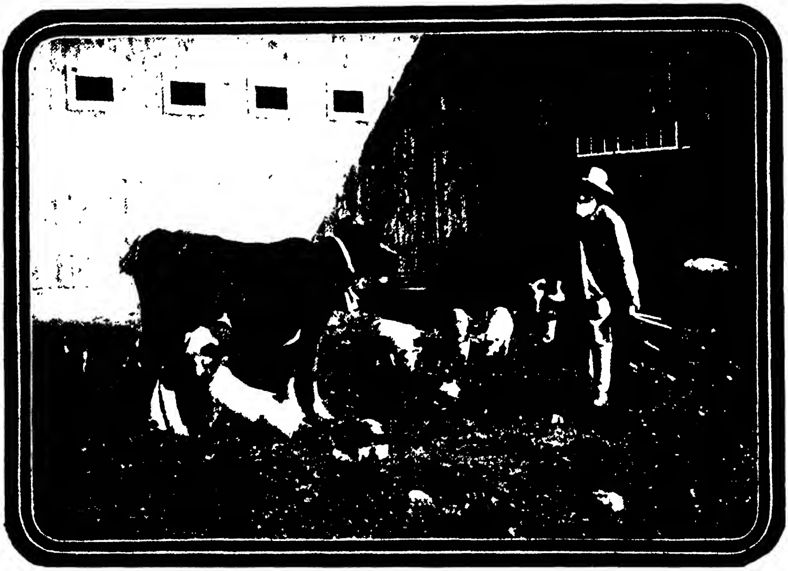

FIG. 15. The contented cow, but an example of poor dairy farming.

of fat; but the last, the strippings, will test very high, often up to 8 to 10 per cent.

Van Slyke of the New York Station analyzed the different portions of the milk of a Guernsey cow, with the following results:

	Pounds of Milk	Per Cent of Fat
First portion	3.2	0.76
Second portion	4.1	2.60
Third portion	4.6	5.35
Fourth portion	5.8	9.80

The practical lesson to be drawn from this is that milking should be done efficiently and completely.

Age of Cow. As already pointed out, the richness of a cow's milk is very largely determined by heredity. She will not produce rich milk during one lactation period and poor milk during another. However, age has its influence. Normally there is a marked increase, from year to year, in the quantity of milk given, with a tendency to a slight increase in the fat content, until a cow reaches maturity. Then, in the ordinary course of events, we may look for a gradual decline. The following is quoted from Eckles, whose investigations were both extensive and thorough:

> On the average, a well-grown two-year-old may be expected to produce 70 per cent, a three-year-old 80 per cent and a four-year-old 90 per cent of the milk and fat that she will produce when mature. . . . The average fat-content remains practically constant from year to year, except that after the cow is eight or nine years old the percentage of fat always declines slowly and gradually with advancing years.

Advance in Lactation. This is a factor that materially influences both the quantity of milk produced and its fat content. When a cow freshens she will probably, if in reasonably good condition, produce milk with a slightly higher percentage of fat in it than there will be a little later. With this exception, the quantity of milk produced and the percentage of fat in it usually remain fairly constant during the first three or four months, after which there is a gradual decline in the quantity of milk produced and a steady increase in its richness. But cows differ very widely in the rate of increase in the fat content of their milk as they advance in their lactation period. The table on page 48 gives the records of two cows in the same Canadian herd, both of which freshened in the spring and at practically the same time—also the average for fourteen cows at the Geneva Station:

Feed of Cows. There was at one time a very general belief, which still has its advocates, that the percentage of fat in milk varies with the nature of the food the cow receives; but many investigations made both in America and in Europe have shown that, practically speaking, the richness of a cow's milk is not influenced by her food. A narrow ration, one made up quite largely of concentrates rich in protein, will stimulate the milk flow, a fact which is well known and made use of by those experienced in the fitting

Stage of Lactation and Fat Content of Milk

Month No.	Cow No. 1		Cow No. 2		Geneva (14 cows)	
	Pounds of Milk	Per Cent of Fat	Pounds of Milk	Per Cent of Fat	Pounds of Milk	Per Cent of Fat
1	546	3.4	614	3.3	753	4.02
2	618	3.4	704	3.2	780	3.74
3	622	3.5	714	3.7	714	3.71
4	723	3.5	721	3 8	636	3.84
5	714	3 7	693	4 1	588	3.87
6	636	3.9	627	4.4	594	3.90
7	601	4 0	591	4.6	570	3.94
8	540	4.1	502	5.1	480	3.89
9	427	4.1	461	5.3	375	3.92
10	214	4.2	47	7.6	282	4.19
11	...	...	...	...	168	4.58

and feeding of cows for high official records; but it does not increase the percentage of fat in the milk.

Observations by the Copenhagen (Denmark) Station over a period of ten years, and including about 2000 cows, led the observers to conclude that foods high in protein content may possibly raise the fat content of the milk to the extent of 0.1 per cent—a very slight increase if actually an increase at all. Lindsay of the Massachusetts station found that a ration with a large excess of protein stimulated the milk flow to the extent of 15 per cent, but he concluded that the percentage of fat in the milk is not influenced by the food a cow receives.

The addition of such abnormal foods as tallow, lard, palm and oleo oils to a cow's ration, or such a radical change of food and environment as from stable to pasture conditions, may cause a temporary change in the percentage of fat in a cow's milk. The change, however, is only temporary.

Environment. Such unfavorable conditions as exposure to inclement weather, sudden changes in temperature, and poorly ventilated barns will cause a decrease in the milk flow. Experienced cheese makers and buttermakers have noted a very serious falling off in the output of their factories within a comparatively short time, when the cows were exposed to low temperatures and cold storms. Under continued exposure to unfavorable environment there may be, at first, a temporary increase in the percentage of fat in the milk.

Reasonable exercise, under suitable weather conditions, is favorable both to health and to a large production, but excess of exercise is not desirable. Where cows are confined to the stable, without exercise, the production may be quite satisfactory, but these conditions are detrimental to the health of the animal and, in the author's opinion, are contributory to the spread of tuberculosis in a herd. In Denmark it is the common practice to keep the cows closely confined, without exercise, during the winter months, and tuberculosis is very prevalent among the herds of that country.

To secure the best results we must study the comfort of the animal, and under the head of comfort we include favorable temperature, clean healthful surroundings, and the avoidance of rough treatment and excitement.

Condition of Cow. If a cow be in a high state of flesh when she freshens, her milk will test much higher during the first few weeks than it otherwise would. Investigations made by Professor Eckles of Minnesota University bring this point out very clearly. We submit the following table based upon work done by him:

STAGE OF LACTATION AND FAT CONTENT OF MILK

Time after Calving	No. 207	No. 217	No. 300
Days	Per Cent	Per Cent	Per Cent
2	5.8	4.4	4.5
5	4.8	4.2	4 2
10	3.9	3.5	4.1
15	3.2	3.7	3.9
20	2.5	3.4	3.6
Months			
3	2.6	3.0	3.6
6	2.4	3.5	4.0
9	3.0	3.4	
12	3.3	4.1	
Av. for Year	2.8	3.4	3.55

Compare the first part of this table with the first part of the preceding table (p. 48) in connection with "Advance in Lactation Period."

On the other hand, Eckles found that when a cow begins to put on flesh there is the very opposite tendency, namely, for the percentage of fat in her milk to decline.

PART II

VARIATION OF FAT IN CREAM

The percentage of fat in cream delivered to creameries or for city trade varies considerably from day to day, and a great deal of dissension arises from the fact that the producer does not always understand all the factors responsible for this wide variation.

Extensive work has been done by Professor O. F. Hunziker, Purdue University, and similar work has been carried on at the Danish Experiment Station at Copenhagen. The work done at Purdue and other experiment stations plainly and conclusively shows that there are a great variety of factors and conditions which control the richness of cream. These factors influence the richness of the cream before it leaves the farm and cannot be controlled by the creameryman, who receives the cream after it has been separated. It is physically impossible to produce cream of exactly the same richness from different skimmings under the gravity method of creaming. It is impossible so to operate the spoon, ladle, or skimmer as to remove the same amount of skim milk with the cream each time. Where the skim milk is drawn from the bottom of the can it is equally impossible so to gage the operation as to leave cream of the same richness in the can at each skimming. Gravity cream, or cream obtained by gravity skimming, is sure to vary in richness, and it is not difficult for the producer to realize the causes of variations under this method of creaming. It is more difficult, however, to convince him that the richness of the cream will vary where the small centrifugal or farm separator is used. The separator is one of the most perfect pieces of farm machinery in use, and is accordingly expected to do nearly perfect work. It is only reasonable that the user of the small centrifugal machine will expect to produce a uniform quality of cream; hence, when he sells this cream and finds that the test is not the same as it was on the previous day, he suspects that something is wrong. The small farm separator does produce the same richness of cream from different skimmings, provided that it is adjusted properly, that it is operated in strict accordance with directions which accompany it, and that the richness, condition, and temperature of the milk, and the proportion of water or skim milk used in flushing the bowl to the amount of milk separated, are the same. (See also Chapter 6.)

The following are the chief factors which influence the percentage of fat in cream:

1. Cream screw adjustment.
2. Richness of milk.
3. Rate of inflow.
4. Speed of machine.
5. Temperature of milk.
6. Amount of water or skim milk used to flush the bowl.

The Cream Screw. The richness of the cream obtained from any farm separator is primarily determined and regulated by the cream screw. The centrifugal separator has two main outlets, namely, the skim-milk outlet, located near the periphery or outer wall of the bowl, and the cream outlet, located near the center of the bowl.

When the milk enters the revolving bowl it is separated into two layers, the skim milk and the cream. The skim milk, being heaviest, is thrown against the walls of the bowl where it escapes through the skim-milk outlet. The cream is forced toward the center of the bowl, where it rises and is discharged through the cream screw or cream outlet. The cream screw is a small threaded bolt with a very minute opening. This bolt can be turned so as to move the opening nearer or farther from the center of the bowl. When turned toward the center it delivers richer cream, because a smaller proportion of the milk is taken as cream. When turned out from the center it delivers thinner cream, because a larger proportion of the milk is taken as cream.

The Skim-milk Screw. Many modern cream separators have skim-milk screws instead of cream screws. The principle of operation is different in the sense that this screw regulates the size of opening of the skim-milk outlet, whereas the cream screw changes the position of the cream outlet with respect to distance from the center of the bowl. The size of the outlet is not changed.

If the skim-milk screw is adjusted to reduce the outlet, then more cream is forced through the cream outlet and vice versa. Naturally more cream causes a lower fat test.

Effect of Richness of Milk on Richness of Cream. The richer the milk, the richer will be the cream. With the cream screw set to deliver a certain and definite richness of cream and all other conditions normal, the separator will deliver a definite ratio of skim milk and cream. This ratio varies according to the way the cream screw is set. Under average conditions it may be about 85 to 15; that is, for each 100 pounds of milk separated the separator delivers 85 pounds of skim milk and 15 pounds of cream. If all conditions are the same, this ratio of skim milk to cream remains constant. Changes in the richness of the milk cannot alter the proportion of skim milk to cream delivered. No matter how rich or how poor the milk, each 100 pounds of milk will yield 85 pounds of skim milk and 15 pounds of cream.

But because practically all the fat goes into the cream, the cream will contain more fat from the separation of rich milk than from thin milk. This is graphically illustrated in Fig. 16.

The illustration (Fig. 16) conclusively shows that, all other conditions being the same, 3 per cent milk produces 20 per cent cream, 4.5 per cent milk produces 30 per cent cream, and 6 per cent milk produces 40 per cent cream. Changes in the richness of milk cause changes in the richness of the cream. Any condition, therefore, that affects the richness of the milk will also influence the richness and the test of the cream.

Conditions That May Cause Changes in the Richness of the Milk. During the early summer months the milk is usually comparatively low in butterfat, caused by such factors as the freshening of the cows, change from dry feed to succulent pasture, and a natural and inherent tendency of the cows toward a decrease in the richness of their milk in early summer. Toward fall and early winter the opposite is true. The advanced state of the period of lactation and the change from succulent to dry feed cause the milk to become richer in fat. It is obvious, therefore, that in the fall and winter the cream test tends to be higher than in spring and early summer.

Again, it frequently happens that even in winter there is a sudden drop in the cream test. This may be due to the fact that some of the cows yielding rich milk dry up or that some cows come in fresh or a new animal may be brought into the herd.

The seasonal variations in the richness of the cream may be reduced by turning out the cream screw a trifle in the fall and by turning it in during the spring.

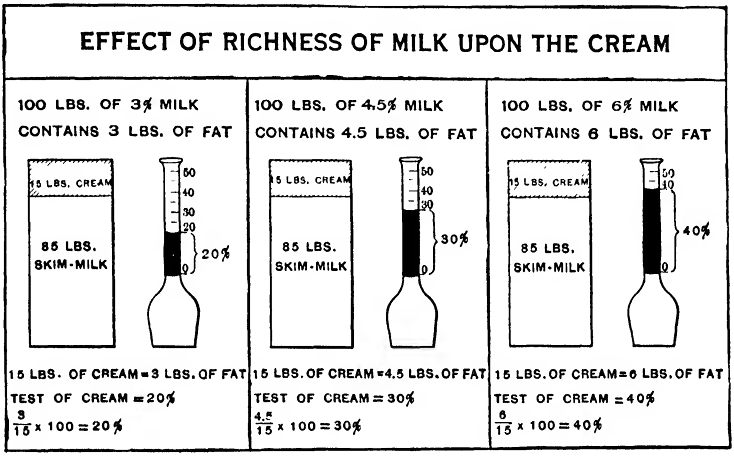

FIG. 16.

Effect of Rate of Inflow on Richness of Cream. The greater the amount of milk passing through the separator of a definite capacity per hour, the thinner will be the cream.

The skim-milk outlet of the bowl is constant. It can discharge so much skim milk and no more. It offers the first available exit for the milk in the bowl. Since it is located at the periphery of the bowl toward which the skim milk is forced, it discharges skim milk.

All the milk that flows into the bowl in excess of what the skim-milk outlet can discharge leaves the separator through the cream outlet or the cream screw. The cream outlet, being located near the center of the bowl where the cream gathers, delivers cream.

The cream outlet then serves as the overflow. The greater the amount of milk running into the bowl in excess of the capacity of the skim-milk outlet, the greater is the overflow, the more milk will leave the bowl through the cream outlet, and the thinner will be the cream. If the separator is so adjusted that, under normal conditions, each 100 pounds of milk produces 85 pounds of skim milk and 15 pounds of cream, a 300-pound capacity machine will deliver $85 \times 300 \div 100$, or 255 pounds of skim milk, and the remainder, the overflow, will be cream. In this case the amount of cream discharged will be 45 pounds $(300 - 255 = 45)$. If the separator is forced beyond its capacity, that is, if more than 300 pounds of milk

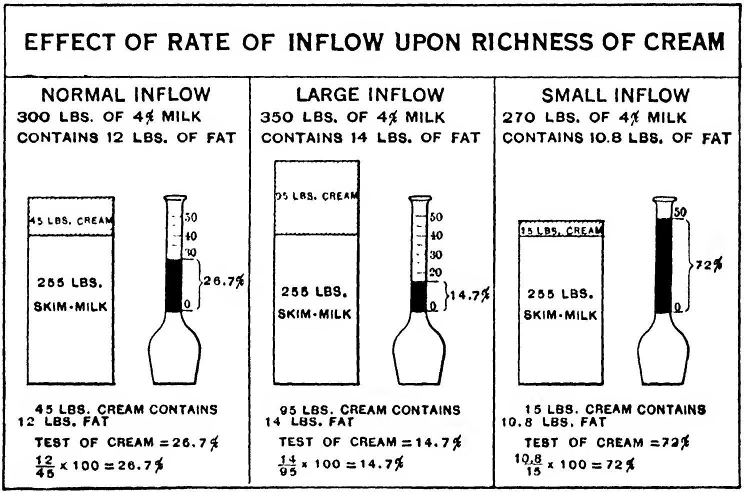

Fig. 17.

are run into the machine, the skim milk discharged remains the same and the cream discharged receives the extra milk. Running 350 pounds of milk into the machine, for example, causes the separator to yield 255 pounds of skim milk and 95 pounds $(350 - 255 = 95)$ of cream. If the milk inflow is reduced below the capacity of the cream, say to 270 pounds, the skim milk discharged remains the same (255 pounds) and the cream discharged is 15 pounds $(270 - 255 = 15)$. The effect of these variations in the rate of inflow on the richness of the cream is shown in Fig. 17.

The diagram above shows that almost any richness of cream may be obtained from the same milk and the same separator according to the amount of milk that flows into the bowl per hour. A normal inflow produced 26.7 per cent cream, a large inflow produced 14.7 per cent cream, and a small inflow produced 72 per cent cream.

Even the fullness of the pan or tank from which the milk runs into the bowl affects the richness of the cream. The fuller the tank the more rapidly will the milk flow into the bowl, owing to a few inches of additional pressure. If the tank is kept filled to the brim, the cream will be thinner than when the tank remains only one-third full.

Every separator is equipped with a simple device called the "Float" to regulate the inflow. The float fits into the receiving cup of the bowl. When too much milk flows into the bowl the float rises and partly shuts off the outlet of the milk supply tank. When too little milk runs into the bowl the float recedes and the supply tank delivers more milk.

The simplicity of the float has had a tendency to belittle its value in the mind of the average dairyman, with the result that on many farms it has been discarded. If the marked effect of the rate of inflow on the richness of the cream is borne in mind, it seems unfair to accuse the creamery of inaccurate testing when the separator float is a conspicuous part of the scrap pile on the farm.

Effect of Speed of Machine on Richness of Cream. The speed of the revolving bowl produces the force—centrifugal force—which drives the skim milk out of the bowl. The greater the speed, the greater the centrifugal force and the more rapidly the skim milk leaves the bowl. An increase in the speed, therefore, forces more skim milk through the skim-milk outlet. This means less milk for the cream outlet and consequently richer cream. A decrease in the speed forces less skim milk through the skim-milk outlet, more milk has to be discharged through the cream outlet, and the cream, therefore, is thinner.

These facts were established experimentally. A separator was so adjusted that, when run at normal speed (60 turns of crank per minute), it delivered 90 pounds of skim milk and 10 pounds of cream. When the speed was lowered to 25 turns of the crank per minute, the skim-milk outlet discharged only 81 pounds of skim milk, increasing the amount of cream delivered to 19 pounds. When the speed was raised to 75 revolutions per minute, the skim milk discharge increased to 93 pounds, reducing the amount of cream to 7 pounds. The effect of these variations of speed on the richness of the cream are shown in Fig. 18.

Figure 18 demonstrates conclusively that high speed yields rich cream and low speed yields thin cream. At normal speed, the cream tested 44 per cent fat, at low speed 11 per cent fat, and at high speed 63 per cent fat. The very low test of cream from a low-speed separation is, in part, due to the fact that a large amount of fat (about one-half the fat of the milk) is lost in the skim milk.

How to Run the Separator at the Right Speed. The proper speed, indicated on the crank of the machine, varies from about 40

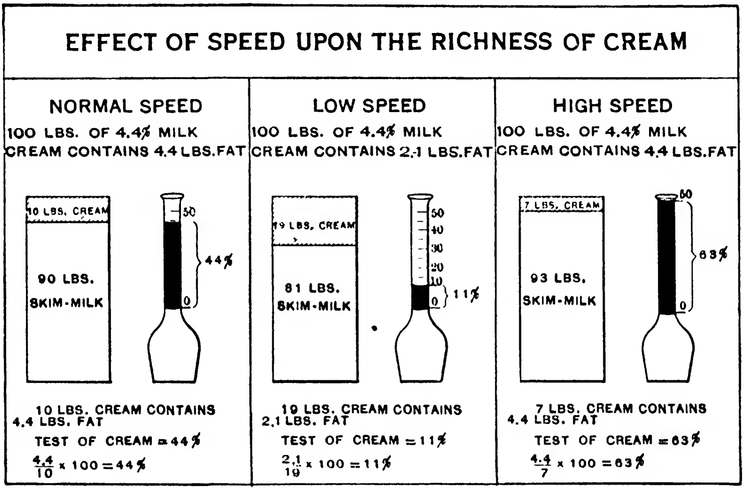

FIG. 18.

to 60 turns of the crank per minute, according to the make of the separator. If a separator is to yield cream of uniform richness, it must be given the same speed at each skimming. This is possible only if the operator times himself frequently, counting the revolutions of the crank with watch in hand, or by a patent speed indicator. The absence of this precaution renders the work unreliable. The general tendency on the part of the operator is to overestimate the amount of work he puts into the machine; the machine is run at too low speed. Even the same operator may vary the speed very considerably at different times, depending on his frame of mind and physical condition. Again, where different persons operate the machine, there can be but little uniformity of speed, unless each person makes an effort frequently to count the crank revolutions by the watch. A gasoline engine or some constant power will tend to give a more uniform cream than a machine operated by hand.

Effect of Temperature on Richness of Cream. The higher the temperature, the thinner the cream. The temperature influences the rate of inflow. The warmer the milk, the more rapidly will it run from the supply tank into the bowl. Since the capacity of the skim-milk outlet is fixed, the increased inflow of the milk is discharged through the cream outlet, producing a thinner cream. Experimental results showed that when the separator was so adjusted

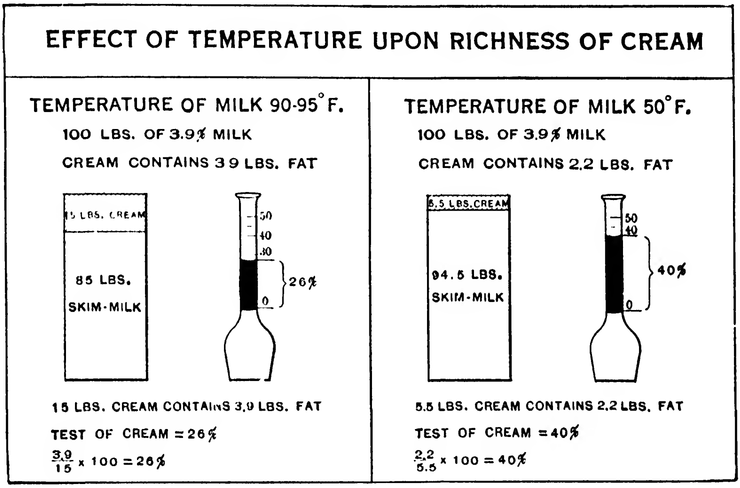

Fig. 19.

as to yield 15 pounds of cream and 85 pounds of skim milk from every 100 pounds of milk separated at 90° F., a drop in the temperature to 50° F., caused the amount of cream delivered to decrease to 5.5 pounds and the skim milk to increase to 94.5 pounds. These results are graphically illustrated in Fig. 19.

The results expressed in Fig. 19 show that, when the temperature of the milk is decreased below normal, the richness of the cream increases. At 90° F., the cream contained 26 per cent fat. At 50° F., it contained 40 per cent fat. The increase in the test of the cream from the cold milk would be still greater if it were not for the fact that at that temperature a large amount of fat is lost in the skim milk.

The Proper Temperature for Separation. The best practical temperature at which to separate the milk on the farm is about 90° F. The milk is never in better condition for separation than immediately after it is drawn. It then has a temperature of about 90° F. to 95° F. If the milk is allowed to cool to a much lower temperature before it is run through the separator, there is bound to be a considerable variation in the cream test and also an increased loss of fat in the skim milk.

Effect of Amount of Water or Skim Milk Used to Flush the Bowl. The more water or skim milk used to flush the bowl, the thinner will be the cream. At the conclusion of the separation there remains in the bowl and in the cream-discharging pan a considerable quantity of cream. In order to save this cream it is necessary to flush the bowl with water or with skim milk. If enough water or skim milk is used, the cream remaining in the separator is flushed out and discharged into the cream can.

The extent to which the cream test is lowered by flushing the bowl will depend on the amount of water or skim milk used, the manner in which it is added, and the amount of milk separated.

If the water or skim milk is just enough to rinse out the bowl and the pan or tank thoroughly, the richness of the cream is not materially changed. An excess of water or skim milk may cause a considerable decrease in the richness of the cream.

If the water or the skim milk is poured into the supply tank and is allowed to run into the machine gradually, most of it will escape through the skim-milk outlet and the richness of the cream will be changed but very little. If the water or skim milk is poured directly into the receiving cup of the bowl, with the float discarded, it will run into the bowl much more rapidly and more of it will get into the cream.

The smaller the amount of milk used for the separation, the more the cream is thinned down by the flushing.

Experimental data show that the cream test may be lowered from 1 to 10 per cent according to the amount and conditions of the flushing. Enough water or skim milk has been used when the cream discharge begins to appear watery. Hot water or warm milk will drive the cream out of the bowl more quickly and may produce a higher-testing cream.

The Proper Richness of the Cream. Cream that is too thin is not satisfactory because it leaves but a small amount of skim milk for the use of the dairy farmer, it increases the cost of transportation, it sours and spoils more rapidly, it prohibits the use of a reasonable amount of starter for ripening at the creamery, it does not churn out exhaustively, and it yields an excessive amount of buttermilk, augmenting the loss of fat and therefore reducing the churn yield.

Cream that is too thick is undesirable because it may cause the separator to clog, it increases the loss in handling, it is difficult to sample properly, and it interferes with the accuracy of the test.

The most satisfactory cream for buttermaking is that which tests about 30 to 40 per cent fat. It is desirable to produce somewhat richer cream in summer than in winter to prevent excessive souring in summer and difficult handling in winter.

Effect of These Factors upon the Skimming Efficiency of the Separator. *The richness of the milk* has no effect on the completeness of the skimming.

The richness of the cream, with reasonable limits, has no effect on the completeness of the skimming. The skimming of very rich cream causes a large loss of fat in the skim milk in certain makes of separators, owing to the clogging of the machine.

The rate of inflow greatly affects the completeness of the skimming. If more milk is run into the machine than the capacity of the machine calls for, there is excessive loss of fat in the skim milk. If the rate of inflow is reduced below the capacity of the skim-milk outlet, the separator delivers no cream at all.

The speed of the separator greatly influences its skimming efficiency. Excessive speed does not increase the completeness of the skimming. Insufficient speed increases the loss of fat in the skim milk. A separator run at half speed may cause one-half the fat of the milk to be lost in the skim milk.

The temperature of the milk affects the skimming efficiency of the separator. For all practical purposes a temperature of 90° F. causes efficient skimming. At lower temperatures there is excessive loss of fat in the skim milk.

The amount of water or skim milk used to flush the bowl regulates the amount of fat lost in the bowl and pan. If the bowl is not flushed at all, or insufficiently, varying amounts of fat may be lost. If the bowl is flushed until the cream discharged is watery, most of the fat in the bowl and pan is recovered and saved.

QUESTIONS

1. List the causes of changes and variations in the fat content of milk.
2. Give the average fat test of milk from the leading dairy breeds of cattle.
3. What may be the extremes in richness of the first and last milk drawn from the udder?
4. List the factors causing variations in the test of cream from a cream separator.
5. Show by calculation the influence of the fat test of milk on the fat test of the cream.
6. Why will overfeeding of a separator produce thinner cream and incomplete separation (loss of fat in the skim milk)?
7. Explain why underfeeding of the separator produces a richer cream.
8. Explain how vibration of the separator bowl causes extra losses of fat in the skim milk.

CHAPTER 5

CARE OF MILK AND CREAM ON THE FARM

The production and care of milk and cream on the farm are tasks of major importance. The quality of all dairy products depends upon clean wholesome milk from healthy cows. There are so many factors concerned in the handling of cows and in the handling of milk and cream that detailed discussion becomes a repetition and may be tedious.

Fig. 20. Washing cow's udders, teats, and flanks before milking. Courtesy, Kelly and Clement, *Market Milk*, second edition, 1931, John Wiley & Sons, New York.

It is necessary to call the attention of producers to the factors needing constant attention. The word *constant* is used in a very definite sense. Sanitary conditions of production cannot be complied with for a day and then neglected. The meeting of requirements must be established on a routine basis and must be carried out in detail every day.

The score card for dairy farms which is used by the Federal Bureau of Dairy Industry is reproduced here as a guide in the improvement of the milk and cream supply.

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF DAIRY INDUSTRY

SANITARY INSPECTION OF DAIRY FARMS

SCORE CARD

Owner or lessee of farm..
P. O. address............................ State..................
Total number of cows............. Number milking.................
Gallons of milk produced daily..................................
Product is sold by producer to families, hotels, restaurants, stores, or to..............................dealer. (Check which.)
For milk supply of...
Permit No............... Date of inspection ...., 19
REMARKS: ....
....
....
....
....
....
....
....
....
....
....
....

(*Signed*) ....
Inspector

EQUIPMENT	SCORE Perfect	SCORE Allowed	METHODS	SCORE Perfect	SCORE Allowed
COWS			**COWS**		
Health	6	......	Clean	8	......
Apparently in good health......1			(Free from visible dirt, 6.)		
If tested with tuberculin within a year and no tuberculosis is found, or if tested within six months and all reacting animals removed 5			**STABLES**		
(If tested within a year and reacting animals are found and removed, 3.)			Cleanliness of stables	6	......
Food (clean and wholesome)	1	....	Floor........2		
Water (clean and fresh)	1	....	Walls........1		
STABLES			Ceilings and ledges........1		
Location of stable	2	..	Mangers and partitions........1		
Well drained........1			Windows........1		
Free from contaminating surroundings........1			Stable air at milking time	5	......
Construction of stable	4	....	Freedom from dust........3		
Tight, sound floor, and proper gutter........2			Freedom from odors........2		
Smooth, tight walls and ceiling 1			Cleanliness of bedding	1	......
Proper stall, tie, and manger . 1			Barnyard	2	......
Provision for light: Four sq. ft. of glass per cow	4	....	Clean........1		
(Three sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1. Deduct for uneven distribution.)			Well drained........1		
Bedding	1		Removal of manure daily to 50 feet from stable	2	......
Ventilation	7	...	**MILK ROOM OR MILK HOUSE**		
Provision for fresh air, controllable flue system........3			Cleanliness of milk room	3	......
(Windows hinged at bottom, 1.5; sliding windows, 1; other openings, 0.5)			**UTENSILS AND MILKING**		
Cubic feet of space per cow, 500 ft........3			Care and cleanliness of utensils	8	......
(Less than 500 ft., 2; less than 400 ft., 1; less than 300 ft., 0)			Thoroughly washed........2		
Provision for controlling temperature........1			Sterilized in steam for 15 minutes........3		
UTENSILS			(Placed over steam jet, or scalded with boiling water, 2.)		
Construction and condition of utensils	1		Protected from contamination..3		
Water for cleaning	1		Cleanliness of milking	9	......
(Clean, convenient, and abundant.)			Clean, dry hands........3		
Small-top milking pail	5		Udders washed and wiped........6		
Milk cooler	1		(Udders cleaned with moist cloth, 4; cleaned with dry cloth or brush at least 15 minutes before milking, 1.)		
Clean milking suits	1	....	**HANDLING THE MILK**		
MILK ROOM OR MILK HOUSE			Cleanliness of attendants in milk room	2	......
Location: Free from contaminating surroundings	1	....	Milk removed immediately from stable without pouring from pail	2	......
Construction of milk room	2	......	Cooled immediately after milking each cow	2	......
Floor, walls, and ceilings........1			Cooled below 50° F.	5	......
Light, ventilation, screens........1			(51° to 55°, 4; 56° to 60°, 2.)		
Separate rooms for washing utensils and handling milk	1	......	Stored below 50° F.	3	......
Facilities for steam	1	......	(51° to 55°, 2; 56° to 60°, 1.)		
(Hot water, 0.5.)			Transportation below 50° F.	2	......
			(51° to 55°, 1.5; 56° to 60°, 1.)		
			(If delivered twice a day, allow perfect score for storage and transportation.)		
Total	40	......	Total	60	......

Equipment............... + Methods............ = ... **Final Score**

NOTE 1.—If any exceptionally filthy condition is found, particularly dirty utensils, the total score may be further limited.

NOTE 2.—If the water is exposed to dangerous contamination, or there is evidence of the presence of a dangerous disease in animals or attendants, the score shall be 0.

Attention is directed to the fact that 60 per cent of the rating is based upon methods and 40 per cent upon equipment. This fact is very definite assurance that suitable equipment alone does not insure good milk and cream. Less suitable equipment may be used in conjunction with approved methods and the result may be entirely satisfactory. However, the importance of healthy cows, suitable barns, sanitary milk houses, etc., must not be underrated.

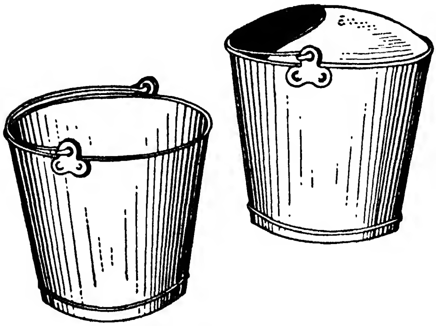

FIG. 21. Small-mouth milking pail made from an ordinary milk pail by the addition of a hood. Courtesy, Kelly and Clement, *Market Milk*, second edition, 1931, John Wiley & Sons, New York.

Licensing Plan for Improving Milk Quality. Matt Wallrich, speaking to a group of farmers at Eau Claire, Wisconsin, in 1936, outlined a method to improve farm conditions.

1. All farms selling any part of their dairy produce shall be licensed by the state at $1.00 per farm.
2. At the end of the first year, and required for relicensing:
   a. Standard cooling tank.
   b. Standard milk-handling equipment.
3. At the end of the second year, and required for relicensing:
   a. Milk house or milk room built according to requirements of the United States Board of Public Health.
4. At the end of the third year, and required for relicensing:
   a. Properly lighted barn.
   b. Impervious cow stable floor.
   c. Standard gutters.
5. At the end of the fourth year, and required for relicensing:
   a. Elimination of hogs and chickens from the cow stable.
   b. Manure to be kept in a yard other than the cow yard.

Many producers would not care to submit to such requirements. Again the question arises as to the best methods to bring about acceptable conditions.

Improvement of City Milk Supplies. Many milk distributors have established very suitable conditions for procuring good milk by:

a. Grading and paying for grades with attractive price differentials.

b. Frequent laboratory reports to producers on grades given with suggestions for improvement.

c. Individual farm inspection.

Better Cream for Creameries. The creamery industry has lagged in its efforts to improve supply. Quite recently some states have enacted laws which require grading, price differentials between the grades, and rejection of unfit cream. Other states are proceeding with more rigid inspection, using established pure-food laws. Individual creameries and state and regional creamery organizations are making commendable efforts to improve conditions voluntarily. Trends are very definitely in the direction of better products.

The dairy industry must keep pace with all other food industries in the production of high-quality products which comply with all federal and state regulations governing purity and sanitary handling and packaging. All efforts of dairy-products manufacturers must center on better raw material, and improvement of milk and cream supplies is fundamental.

Outline of some essentials in the production of high-grade milk:

1. Provide spacious, well-lighted, well-ventilated stables with impervious floors and gutters.
2. Maintain healthy herds and use clean wholesome feeds.
3. Use plenty of clean bedding and remove manure often.
4. Clip cows' udders. Use damp cloth to clean udders.
5. Wear clean clothes.
6. Milk with clean, dry hands.
7. Use standard, well-tinned equipment, previously treated with plenty of hot water or chlorine solution.
8. Separate or cool milk at once.
9. Wash the cream separator after each run.
10. Do not mix warm cream with cold cream.
11. Keep milk house clean and ventilated. Screen it against insects.

12. Cooling-tank water to be changed often.
13. Deliver milk or cream promptly. Protect it against heat, dust, and insects en route.

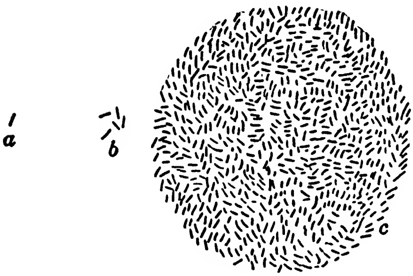

FIG. 22. Showing the effect of temperature upon the growth of bacteria. *a*—single bacterium; *b*—its progeny in 24 hours at 50° F.; *c*—its progeny in 24 hours at 70° F. (750 bacteria). Courtesy, Kelly and Clement, *Market Milk*, second edition, 1931, John Wiley & Sons, New York.

Care of the Cream Separator. A cream separator is a high-speed machine requiring proper mechanical care and oiling if it is to serve well for its normal life. Details of operation are given in instruction books.

In discussing milk and cream quality we omit the mechanics of operation and proceed to the sanitary aspects and the care of the separator bowl. It is well known that neglect of washing the separator after each run is responsible for much of the second-grade cream marketed. Pails and strainers may not be washed thoroughly, but if they are inverted and dried when not in use they are a much less serious menace to the quality of cream. Unwashed separators

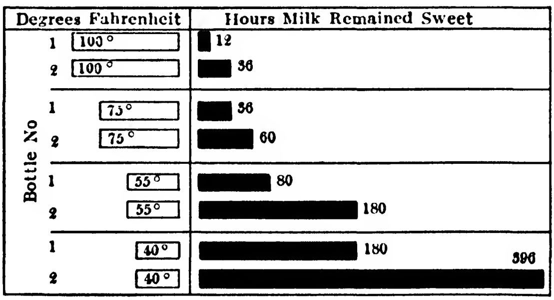

FIG. 23. Diagram showing time necessary to sour milk of high (1) and low (2) bacterial content at different temperatures. Courtesy, Kelly and Clement, *Market Milk*, second edition, 1931, John Wiley & Sons, New York.

permit bacterial growth to an extent beyond imagination. In addition, separator bowls are almost entirely enclosed and retain the odors resulting from bacterial growth. Clean milk passing through an unwashed separator bowl will sour in a relatively short time. All efforts to produce good milk and cream may be entirely nullified by neglect of the separator.

Clean the separator after each run. Use a brush to insure removal of any deposits at uneven surfaces. Use a mild washing powder and do not use soap. Scald all parts of the bowl with plenty

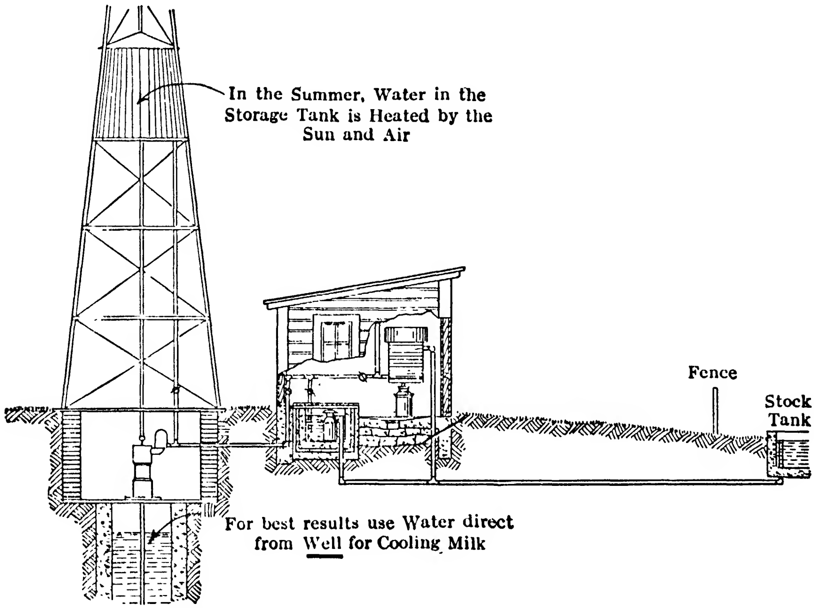

FIG. 24. Arrangement of water supply for milk house. Courtesy, Kelly and Clement, *Market Milk*, second edition, 1931, John Wiley & Sons, New York.

of hot water. Frequent use of chlorine solutions is an additional safeguard.

For detailed instructions on the construction of barns, milk houses, cooling systems, etc., write your state experiment station or the Bureau of Dairying, Washington, D. C. Information on all details in the production of good milk and cream is available in bulletin form from the same sources.

Figures 20 to 25, inclusive, illustrate some of factors and practices on the dairy farm which are fundamental in the production of clean milk. Prompt cooling of milk and cream is necessary to preserve quality until delivered to a dairy plant. Clean, well-ventilated storage rooms are very desirable.

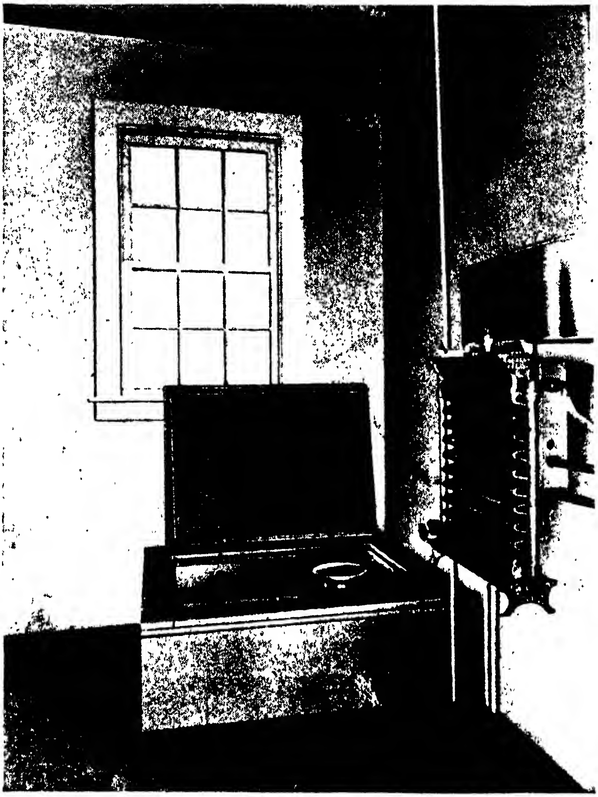

FIG. 25. Milk cooler and insulated storage tank with cover. Courtesy, Kelly and Clement, *Market Milk,* second edition, 1931, John Wiley & Sons, New York.

CONDITIONS WHICH INFLUENCE MILK AND CREAM QUALITY

The production and delivery of good milk and cream depend upon several factors, among which are these:

1. The intensity of dairy farming.
2. Kinds of feed used.
3. Facilities available—barns, labor, milk houses, suitable utensils, cooling, storing, and delivery.
4. Distance from market—condition of roads.
5. Method of transportation.
6. Method of payment for product—quality basis with sufficient price differentials and rejection of undergrade products.
7. Pure food and grading laws—their enforcement.

8. Education of the producer in the need of suitable equipment, constant care, sanitation, prompt cooling of milk and cream, and prompt delivery to the dairy plant.

Successful control and regulation of the quality of milk in market milk areas has been worked out quite satisfactorily. This was necessary at an early date because milk as a food is extremely perishable and is easily contaminated unless suitable facilities are provided and intelligent supervision is supplied. Nathan Straus of New York introduced pasteurized milk into cities. He was aware that many babies did not survive during the summer season. In 1893 he established in New York City a milk depot which provided free, pasteurized milk to all mothers who could not afford to buy it. Medical authorities quickly recognized its value as a safeguard to public health. Shortly the cities made pasteurization of milk compulsory. Surprising as it may seem, only about 47 per cent of all market milk is pasteurized at present. Small towns and villages are extremely unfortunate in not having better regulation of their milk supply.

Cream Separated on the Farm. For economical reasons a large part of the national butter output comes from regions which are sparsely settled and where costs of production are low. The cash returns to the farmer per pound of butterfat are lowest when the fat is sold for buttermaking. Partly because of prices and because of distance from market, cream producers market their product irregularly. Frequently the quality of cream is too poor for use as cream. There would be no market for it. Standardization of acid in sour cream, pasteurization, and churning of the cream to butter do provide means of putting the butterfat into a form which is satisfactory for the consumer. The grade of butter made, however, depends very largely on the kind of cream used. Consumer demand for the better grades of butter, coupled with the persistency of pure-food authorities, is gradually improving the quality of farm-separated cream. Much remains to be done and particularly in the more sparsely settled regions.

The poor-cream problem is much less acute in good farming sections and particularly where dairying has become the main source of the farmers' income. There facilities are better and better methods are used. Greater production per farm increases the frequency of marketing the cream, reduces the costs, and raises the quality. The so-called "syrup-pail producer" is a definite menace to cream quality in any community.

Cream should be separated from clean milk from healthy cows and should be kept cool until delivered to the creamery. The interval between separation and delivery should be as short as possible. Even when cold water is freely used and when conditions of storage are good, cream soon loses its fine freshness and gradually becomes stale. This must be avoided. If cream cannot be kept fresh by the use of farm separators, then we may be compelled to return to daily whole-milk delivery and factory separation of cream. Dr. C. H. Eckles of Minnesota University prophesied such a development in 1928. He saw what had happened in the organization of large diversified dairy-manufacturing plants. Such plants are equipped to manufacture any dairy product that may have a temporary price advantage. Under such conditions the plant manager is in a strong competitive position, as he can pay more for milk, or get greater net profit, or both.

Professor F. H. Abbott of California states that about 80 per cent of the butter made in California is made from sweet cream separated at the creamery. There is really no cream-grading problem under such conditions. Nevertheless, California has been successfully engaged in a quality-improvement program during the past fourteen years. Cream and milk for manufacturing purposes have been inspected and graded by state civil-service inspectors. The buyers in each specified area furnish funds to the state department for handling the work. In some instances two or three inspectors are employed in one district in order that the work may be done effectively. When producers are unable to deliver good milk or cream, inspectors visit the farms and help to improve conditions. The program, which has been very successful, covers the entire state with the exception of a few plants located in isolated mountain valleys.

In California, each creamery is required to have a licensed butter grader. This grader naturally checks the quality of milk and cream arriving at the plants. This requirement is in conjunction with California's legal butter grades, viz.: First Quality, Second Quality, and Third Quality. These are referred to as "consumer's grades," because each retail package must contain a grade identification. Consumer's grades for butter have an indirect influence in causing voluntary cream grading where no state law exists. Washington State has alphabetical consumer's grades. Both the Washington and California laws have an influence on butter-quality improvement in all nearby states which market their surplus butter in the Pacific Coast States.

CHAPTER 6

BUYING AND GRADING CREAM

The buying and grading of cream become a very competitive business as the industry grows older. Competition has always existed but at times has been less keen and less time consuming. Buying of cream and increase or maintenance of volume have become major problems with all types of creameries. A survival of the fittest is at times a most disconcerting problem. Under such conditions the quality of cream is frequently neglected and the quality of butter is lowered. Returns to dairy farmers are reduced. Marketing agencies and consumers are also adversely affected.

These are methods of marketing cream:

1. Cream-truck routes.
2. Door delivery by individual patrons.
3. Direct shipping.
4. Cream stations.
5. Cooperative cream-shipping stations.

Cream-Truck Routes. With improved roads and better automobile trucks, each year more cream is delivered to the creameries in trucks. In general, this has been very beneficial to both cream producers and cream buyers. The routes are made on schedule and the cream is marketed much more frequently and regularly than formerly, when each farmer took the cream to town whenever he happened to go. The length of time cream is held on the farm is a very important factor in cream quality. Several states are now paying attention to the four-day plan of buying cream, which is advocated by the Purdue Agricultural College in Indiana.[1] This is an entirely voluntary plan which has worked quite successfully in southern Indiana and some other regions. It must be conducted on an area basis, which is largely true of any successful cream-grading plan.

Trucking Costs. The usual costs for trucking cream vary from 1 to 2 cents per pound of fat. Some creameries own their trucks and hire drivers; others have contracts with private truck owners, with a possible guarantee of a minimum amount per trip or per trip mile. The costs, 1 to 2 cents per pound of fat, are reasonable except when butterfat prices are high, and most costs rise to some extent. Much depends, of course, on the miles driven, the amount of cream collected, and the kinds of roads encountered. When cream is hauled with trucks a question often arises as to a higher price to be paid for nearby patrons who deliver their own cream. They may feel entitled to the truck-collection costs. In most instances they do not receive more, because the success of the creamery depends on better cream which the routes supply as well as the increased volume for the creamery. The cost of manufacture is reduced, and this raises the net profit to a point which might be commensurate with a higher door-delivery price.

It is interesting to note the recent enactment of a law in Minnesota which requires a charge to be made when trucks collect cream at the farm. The law specifies that a charge of 2 cents per pound of fat be made in all cases, with possible exceptions where satisfactory records show costs to be less. This is another of many regulatory measures intended to remedy unethical trade practices. It is readily understood that a buying station or dairy plant which does not use trucks to gather cream might readily lose a large portion of its business if it did not pay a price high enough to equal local fat prices, plus the cost of truck service. The idea of adding trucking costs to established prices is unsound. It is far better to maintain uniform base prices and make separate charges for extra service.

Route Sampling. Cream is usually gathered on the routes and delivered to the creamery in the producers' cans. This is the preferred method, some reasons for which are:

1. It facilitates grading.
2. It helps preserve cream quality.
3. Saves time.
4. Permits weighing and sampling under acceptable conditions.
5. Trucks may collect more cream and deliver it more promptly.

If truck operators sample and weigh cream on routes, they should be required to pass testers' and graders' examinations and should operate only under the license system. State authorities usually demand compliance with these conditions.

Door Delivery. Door delivery is delivery of cream by the producer. This practice has the distinct advantage of frequent contact of the creamery operator with his patrons. Personal service is often a business getter and a business holder. It has the disadvantage referred to above, that is, irregular delivery, for sometimes cream is held until it is in very bad condition.

Some patrons who market good cream for 8 or 9 months during the year may be very busy during the summer season and neglect the cream to such an extent that a serious quality problem arises.

Direct Shipping. Direct shipping of cream, usually by railway service, has some disadvantages. The realization that this practice often results in lower-grade cream has had a deterring effect. Such cream is shipped in baggage cars and is not refrigerated. During the warm season of the year, cream may be started in good condition and arrive at the creamery as definitely second-grade cream. Factors which usually accompany direct cream shipping often work against quality. The producer may skim a rich cream. It takes much longer to fill a can, and too often the cream is old before it leaves the producer. In regions where dairy farming is conducted as the major farm enterprise and where long shipments are avoided, direct cream shipping may be entirely practicable. Farmers producing but little cream should not attempt direct shipment. It takes too long to get a canful of cream.

Cream Stations. Cream-buying stations as operated by the large central creameries have played an important part in the development of a dairy industry in the central northwestern states. They furnished an early cash market for cream before enough local creameries were built to handle the business. In many instances the farmers in newly settled sections were able to survive because of the cream-station service. The stations furnished a local market and helped develop dairy farming to the point where enough cream was produced to justify the operation of a local creamery.

In the past few years there has been a decrease in the number of stations, attributed to several reasons. Lower prices for butterfat have reduced buttermaking profits. Cream-station buying costs have been reduced some, but they have remained high enough to cause the closing of the stations receiving but little cream. State dairy and food inspection has exacted cream-station improvements which have made greater buying costs.

Overlapping Milk and Cream Routes. The "trade territories" map of Iowa shows the intricate overlapping of territory resulting from intensely competitive creamery operations. (See Fig. 26.) Many of these creameries secure a large part of their supply by cream-truck routes. Where several trucks cover the same territory, the assumption is that each gets a share of the cream produced. In order to get a load, much more territory is covered and the expense climbs in proportion. Not only is it more expensive but trucks remain on the routes more hours and in hot weather there may be a corresponding decrease in the quality of the cream as it arrives at the factory. This survey included one-half the cooperative creameries and one-fourth of all creameries in Iowa.

The Iowa trade territories map is representative of conditions existing in many producing areas. These conditions are not materially altered in sections of greater or lesser intensity of production. They are undesirable from the standpoints of (*a*) costs of collection and (*b*) possible lowered quality of milk and cream. It is a good example of unregulated competition. The industry should take steps to correct the condition. Voluntary regulation is commendable. Of interest is the fact that the Australian Government does regulate these conditions and the present German regime regulates comparable conditions in Germany. Where low volume of product or inefficient operation exists, small plants are forced to join larger ones.

In the cities, six milk wagons may peddle milk in the same alley; but, when the farmer is served by six trucks seeking his patronage, somebody must pay increased cream-procurement costs. Ultimately it is the cream producer.

A very regrettable fact is that many of these creameries are farmers' cooperative plants, and they compete severely with one another. They do not cooperate economically or ethically with a neighbor cooperative factory.

Cream has been bought at stations on a variety of bases.

1. Straight Commission Buying. Usually the equipment and

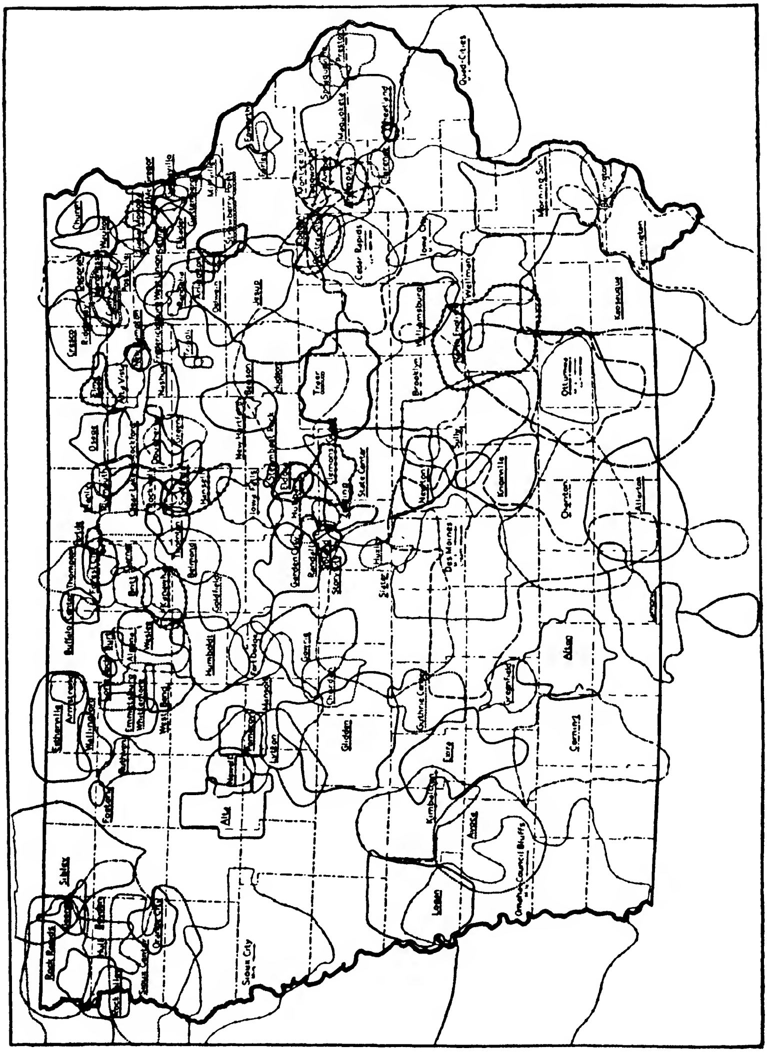

FIG. 26. Trade territories served by 139 Iowa farmers' creameries in 1935. Courtesy Agr. Econ. Division, Iowa State College and Federal Farm Credit Adm. Bull. 14, 1937.

rental of the station has been provided by the company and the station operator has been paid a few cents per pound of butterfat (usually 3 cents) for his services. This encourages him to build volume regardless of quality.

2. Service-Charge Plan.[2] The central creamery fixes the price paid for butterfat. A station service charge of about 30 cents per delivery is made. The station operator's compensation is included in the butterfat price. This naturally causes the producer to hold his cream until the can is full, and the effect on quality of cream is very noticeable.

3. Buying Services Paid for on Quality Basis. Realizing that quality could not be thus neglected, some central creameries paid commission on all first-grade cream and paid none on second-grade cream. Obviously the operator was working for nothing when he bought second-grade cream, unless he paid less for this cream. This, and the service-charge plan were efforts to reduce station buying costs and to improve quality.

4. Delivered Price System.[2] The station operator contracts with the company to sell all his purchases on a definite price basis. One such arrangement was as follows:

Price, 90-Score Butter, Cents per Pound	Price per Pound Fat Creamery Pays Station Operator on Fat Delivered to Central Plant
23 to 27	3 cents less than market price
27 to 32	2 cents less than market price
40 to 43	½ cent more than market price

This plan makes the station operator quite independent in the price he pays. He can build his volume on a higher competing price basis and take less margin. Also it may result in evasion by the central creamery of state antidiscrimination laws. These laws, in brief, are that any chain of cream stations operated by one company must pay the same price at all stations except:

1. Allowance of differences in transportation costs from point of purchase to the central creamery.
2. To meet local price competition.
3. For differences in grade or quality.

The central creamery pays less than the market price when butter prices are low because the overrun is less valuable. Costs of manufacture fluctuate but little compared to market-price changes. Hence, in order to make some profit, fat prices are lower than butter prices. When butter prices are higher, the overrun is more valuable, and the central creamery can pay more for fat than the market price of butter and still make sufficient profit.

Another way of illustrating this plan is:

Price 90-Score Butter Cents per Pound	Central Creamery Delivered Price, Cents per Pound Butterfat
28	28
23	$21\frac{3}{4}$
33	$34\frac{1}{4}$
40	43

Note: Grades other than 90 score may be used but must be uniform throughout the region.

It will be noted that 28 cents is set as the dividing price line. When the market is less than 28 cents, the central creamery price is decreased by 1¼ cents for each 1-cent market decline. If the market price is more than 28 cents, the central creamery price is increased 1¼ cents for each 1-cent market price increase. These figures are based on a 25 per cent overrun, or the fact that nearly 1¼ pounds of butter are made from each pound of butterfat. Of course, 25 per cent overrun is legally unobtainable, but approximate figures may be used in calculating prices.

Cooperative Cream Stations. Producers who are not satisfied with local markets where there is no creamery sometimes organize and operate cream stations of their own. This is not a common occurrence but may prove beneficial to the farmers. Cream trucks and good roads serve to accommodate some sections that may formerly have felt the need of some cooperative organization.

It is to be recommended in some instances that producers do organize cooperative cream stations rather than launch directly into the operation of a creamery. If sufficient patronage of a cream station materializes and it is evident that extra profits are gained, then thought may be directed to the organization of a cooperative creamery. Such a cream station should handle 150,000 pounds, or more, of butterfat annually because this amount should be considered as a minimum for successful creamery operation.

In the building of business in a cooperative cream station, lessons on cooperation may be learned which are essential to the success of the contemplated creamery. Community pride, steadfastness of purpose, and the true cooperative spirit are necessary for success.

Advent of the Cream Separator. During the period, roughly, between 1890-1900, milk was skimmed by power separators either at the local creamery or at special cream-skimming stations operated by the central creameries. Shortly after 1900, hand-operated cream separators gradually eliminated station skimming, and the cream station as we know it today came into existence. This was more economical for the farmer, the creamery, and the cream station. However, in some instances products of lower grade resulted. The time element alone was no doubt the major factor. Formerly, milk had been delivered daily and relatively soon after milking. The milk now passed through the farm separator and the cream was retained at the farm from one to several days. The separators were frequently neglected, and sour cream with off flavors was delivered to the creamery. This condition became very troublesome to the creameryman and has continued to the present day to be a most perplexing problem. Dairy-farm papers, college extension services, creamery operators, and various dairy associations have spent much time and effort in trying to improve conditions. What has actually been accomplished remains rather intangible. The greatly renewed activity of the federal pure-food authorities and the enactment of state cream-grading laws give promise of forcing long-needed improvement.

Cream in Transit. Statements have already been made about delays on the part of the farmer in taking his cream to market. When cream is gathered by automobile truck routes there is considerable opportunity for change in the quality of cream en route. Trucks are usually out 5 hours per trip, and in the summer this may cause cream to warm to atmospheric temperature, and then fermentation and souring may proceed rapidly. In the winter the cream freezes, and difficult sampling and mealy butter may be the result. No state laws specifically cover the transportation of cream except the 24-hour holding limit for cream stations. General laws covering the handling of food products are operative. In a number of states regulations have been adopted or pure-food laws interpreted so as to require these trucks to be covered or enclosed and wet tarpaulins to be kept over the cream in summer. Cream is not to be hauled in enclosed trucks with poultry or other malodorous products. Cream shipped by rail has sometimes been protected by covering the cans with wet burlap bags. This or other means of reducing temperatures should be encouraged.

Minnesota Sixty-Mile Transportation Law. Some years ago the state of Minnesota passed a law limiting the transportation of cream more than sixty miles from the point of production. This was a commendable effort to help solve the poor-cream problem. The law was later repealed because unforeseen results developed. One very

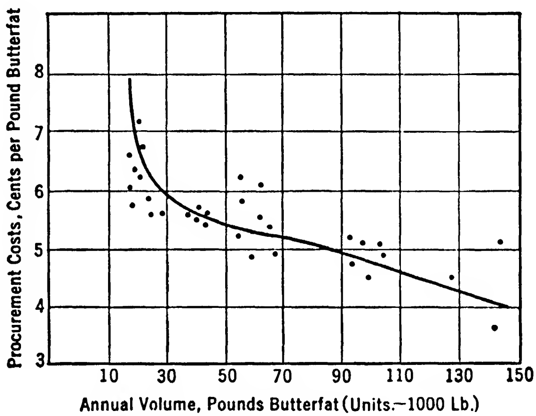

FIG. 27. Relation of volume of butterfat bought to procurement costs. Courtesy of Idaho Exp. Sta., Bull. 193, 1935.[2]

ridiculous procedure was the shipping of cream from many points in Minnesota to adjoining states. From these concentration points the cream was reshipped to the Twin Cities. Minnesota's law of course was inoperative in interstate commerce. Results in such cases were detrimental instead of beneficial to the quality of cream.

Cream Procurement Costs. Undoubtedly cream procurement costs are highest when the cream is bought by cream stations. Average cream-truck-route costs are about 2 cents per pound of fat. Cream-station procurement costs, which include delivery to the central plant, ranged from 3.66 cents per pound to 8.07 cents in a survey in Idaho in 1932.[2] The average of 37 creameries was 5.27 cents. (See Fig. 27.)

PROCUREMENT COSTS PER POUND BUTTERFAT
(Idaho Bull. 193)

Volume in one year	Shortage of butterfat in one year		Shipping costs	Other station costs	Commission rate	Total costs
Pounds fat	Pounds fat	Per cent	Cents	Cents	Cents	Cents
3,467	142	4 0	1.95	2.37	3.0	7.32
8,741	69	0 8	1.92	1.26	3.0	6.18
10,190	144	1.4	1.66	1.13	3.0	5.79
22,728	169	0.7	1.86	0.77	3.0	5.63
33,920	69	0.2	2.35	0.69	3.0	6.04
66,579	70	0.1	1.98	0.59	3 0	5.57
81,480	541	0 7	1.72	0.57	3.0	5.29
134,444	342	0.3	1.88	0.51	3.0	5.39

Idaho Bulletin 193 gives a page of figures on 37 cream stations. Eight out of the 37 are given above and include stations ranging from a low volume to a relatively high volume. The average of the 37 cream stations is as follows:

Volume in one year	Shortage of butterfat in one year		Shipping costs	Other station costs	Commission rate	Total costs
Pounds fat	Pounds fat	Per cent	Cents	Cents	Cents	Cents
36,783	201	0.5	1.77	0 72	2.78	5.27

N. R. Baker,[3] manager of the Fairmont Creamery Company of Columbus, Ohio, gives station procurement figures. (See table, p. 82.)

Holding Cream Raw and Pasteurized at the Creamery. The central creameries hold cream in the original cans and do not process until such time as it may be churned the same day. Cold-water showers spray the stacked cans if other cooling facilities are not provided. Many local creameries pasteurize cream one day and churn it the next. They receive cream Saturday and until late Saturday night. Frequently the largest weekly receipts are on Sat-

	1934	1933	1932	1931	1930	1929	1928	1927	1926	1925
Wages of commissioners.	1.91	1.97	2 16	2.67	2.92	2.85	2.91	2 94	2.76	2.88
Rent, fuel, etc.	0.15	0.15	0.34	0.51	0.54	0.58	0.65	0.49	0.49	0.54
Transportation to plant.	0.65	0.86	1.21	1 56	1.90	2 02	2.11	2 36	2.47	2.63
Total direct station expense	2.71	2.98	3.71	4.74	5.36	5 45	5.67	5.79	5.72	6.05
Cans, depreciation, field man, telephone, and maintenance	0.66	0 48	1.39	1.22	0.90	0 82	0.88	0.98	1.57	2.00
Total buying costs	3.37	3.46	5.10	5.96	6.26	6.27	6.55	6.77	7.29	8 05

(See Fig. 28 for graphical presentation.)

urday. The question arises as to the best method of handling this cream to preserve quality. The cream is dumped into vats. Should it be cooled and held raw, or should it be pasteurized and held as cold as possible until Monday morning?

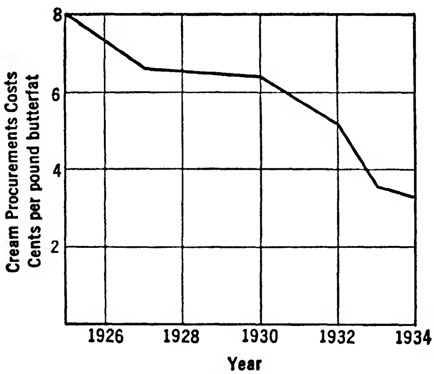

Fig. 28. Ten-year trend in cream station procurement costs in one Ohio creamery. N. R. Baker, Fairmont Creamery Co., Columbus, Ohio.[3]

Some work at the South Dakota station[4] indicates that there may be advantages in holding cream raw if considerable time elapses before churning. Results of trials indicate that higher flavor scores may be obtained when the cream is held raw and is well cooled until it may be processed and churned within a few hours. Pasteurized cream in particular must be held below 45° F. In local creamery operation, the maintenance of sufficiently low temperatures is likely to be neglected. Negligence may be excused with the statement that the cream is pasteurized and therefore quite safe.

As a matter of fact, the acidity in raw cream actually has some preserving power. It inhibits the growth of bacteria which do not thrive in acid media, viz.: protein digesters and liquefiers. These types are often responsible for cheesy and stale odors and flavors.

In the work referred to above, the lower the quality of cream, the greater the difference in scores in favor of holding cream raw. With cream of mild acidity and reasonably clean, differences in butter flavor scores, both when fresh and during six months in storage, were slight.

The proportion of desirable and undesirable flavors and the ap-

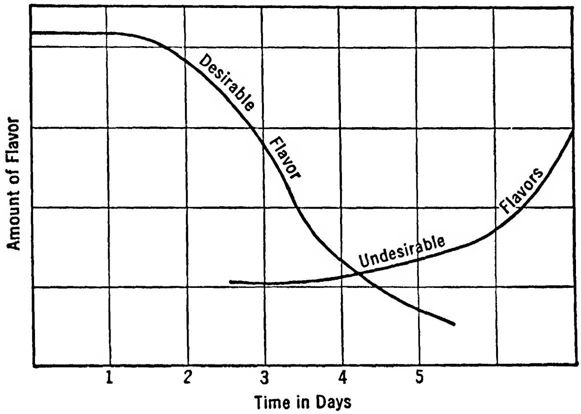

FIG. 29. Theoretical representation of the relation of age of cream to the development of desirable and undesirable flavors.

(NOTE: It must be understood that this is approximate. The maintenance of good flavors and the prevention of development of undesirable flavors are dependent upon the many factors previously discussed. Time is only one of the factors, but it is relatively important.)

proximate time of their appearance are indicated in Fig. 29. This chart portrays only general considerations. Many factors affecting cream quality are discussed elsewhere in this chapter and also in Chapter 5.

At the time of starting this work, the question was submitted to four men. Two of them hold high degrees in dairy technology. The other two have had less technical training but have had years of practical creamery experience, and both are recognized as important dairy leaders. The first two replied that the cream should by all means be pasteurized and held so for the long interval before churning. The latter two wrote that the cream should be held raw and in the original cans if possible, the cans to be refrigerated or stacked and showered with cold water during the long holding period.

Sources of Flavors in Cream. There are four general sources of flavors and odors in cream. These vary in their importance and ranking depending upon the season of the year and other local conditions. They are:

1. Bacteria, yeasts, molds, enzymes.
2. Feeds and weeds.
3. Absorbed flavors and odors.
4. The physical condition of cows.

We have attempted here to list them in order of their importance. It is very possible, in the spring of the year, however, that feeds and weeds may assume first rank. In general, throughout the year the bacteria and contamination are the principal causes of poor cream. Contamination coupled with long holding periods on the farm are to be persistently avoided.

Bacteria, Yeasts, Molds, Enzymes. A few suggestions to diminish the spoiling of cream from bacteria are these:

1. Keep as much dust and foreign material out of the milk and cream as possible. Such material carries millions of bacteria.
2. Cool cream promptly, and keep it as cold as practicable until marketed. (See Fig. 30.) Never mix warm cream with cold cream.
3. Be most careful to keep pails, cans, strainers, etc., well washed, scalded, and dried.
4. Wash the separator after each run. Leave apart to dry. *This* is most important.
5. Finally, market cream often and regularly, not less often than three times per week in summer and two times per week in winter.

Feeds and Weeds. In the spring of the year farmers are often too eager to get cows out to pasture. Some very objectionable weeds, such as garlic, wild onion, stink-weed or French weed, and peppergrass, start early in the spring. The cows will eat these if the grass is short. These weeds produce foreign flavors in milk and cream, and butter from such cream sells at much lower prices. Every effort should be made to keep cows from pastures until sufficient green grass is available. Flavors from these weeds will persist in the body of the cow and taint the milk for as long as twelve hours after the cows are taken from the pasture. Such feeds as rye, cabbage, rape, mustard, alfalfa, and sweet clover will taint the milk somewhat but not to so damaging a degree, although cabbage, rape, and mustard are to be avoided. When cows are removed from such feeds two or three hours before milking, the flavors are much less intense. Advice is given relative to mowing some such

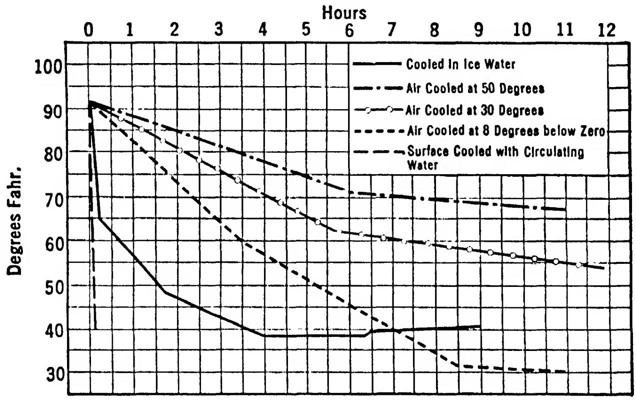

FIG. 30. Comparison of efficiency of methods of cooling milk. Figures obtained in cooling 10 gallons of milk. Air cooling is quite inadequate. Cold-water cooling, properly done, is satisfactory. Surface cooling is highly desirable.

objectionable weeds as peppergrass and French weed. There are times during the summer season and fall when it may be necessary to feed cows in the barn rather than force them to eat weeds. The extra milk production resulting from proper care would well repay the farmer for his efforts, and the creamery would have less difficulties.

Absorbed Odors and Flavors. Cow-barn odors, musty cellar and vegetable odors, kerosene, oil, etc., are examples of absorbed flavors. In most instances they are the results of carelessness and incidental exposures, and the remedies are obvious. When these odors are in cream they are held by the butterfat and are very troublesome.

Physical Condition of Cow. Milk should not be used if cows are known to be sick. It is illegal to sell such milk. Milk from cows with garget is often a source of stale flavors in cream. Cows late in the lactation period may produce milk which is salty or bitter, and it may also be offensive in odor. Such milk is undesirable for cream and butter.

Sediment pads to determine the kinds and amounts of foreign material in milk and cream are of great value to the plant operator

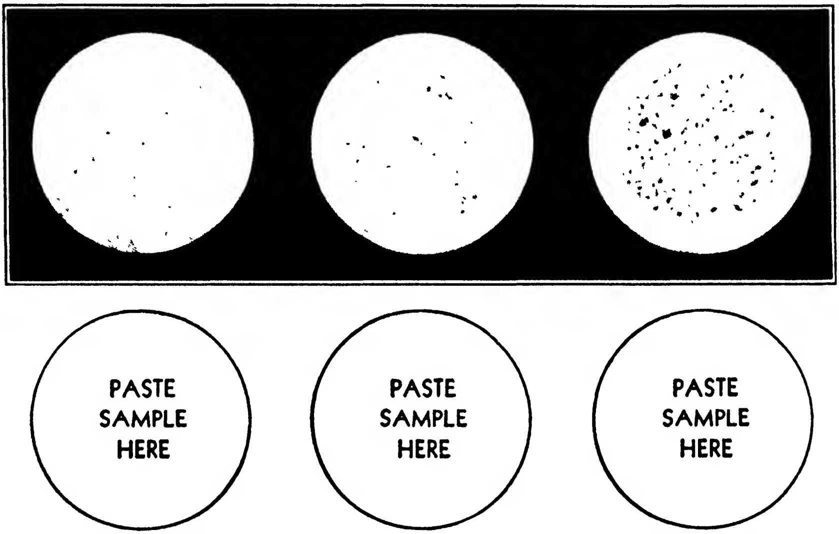

Fig. 31. Standard sediment test pads. Left, good—Center, fair—Right, very poor; cream with such tests (right) is rejected because illegal. Courtesy, Iowa State Department of Agriculture.

in improving quality. Frequently such pads are attached to the patrons' statement or check. (See Fig. 31.)

A complete score card is a further means of helping patrons whose product is substandard.

CREAM GRADING

Three methods or bases for grading cream have been used. (See Olson and Totman.[5]) These are:

1. Acidity basis—that is, sweet or sour.
2. Time basis (four-day plan as sponsored by Purdue University, Lafayette, Ind.).

Suggested Cream Score Card

No.......... Date.................. Name.........................

	Perfect score	Score given	Criticism
Flavor and odor...	45		
Sediment.........	20		
Acidity...........	20		
Container........	10		
Test.............	5		
Total score.......	100		

Grade.........................

Grade of cream	Total score	Flavor score
Special..............................	90 or above	37 or above
No. 1...............................	80 to 89.5	35 or above
No. 2	70 to 79.5	33 or above
Reject..............................	below 70	below 33

Flavor and odor, usual range 33 to 38	Score according to flavor score of butter which can be made; for example 35 = 90-score butter, 38 = 93-score butter, etc.	
Sediment 20............	20	very clean
	17 to 19	fairly clean
	10 to 16	objectionable but usable
	0	illegal
Acidity 20.............	20	0.20% or less
	19	0.21 to 0.30%
	18	0.31 to 0.40%
	16	0.41 to 0.60%
	10	above 0.60%
Container 10...........	10	not rusted, clean, standard can
	7 to 9	soiled, slightly rusted, dented
	0	syrup pails, etc., badly rusted or soiled
Test 5................	5	31% or more
	4	26 to 30%
	3	20 to 25%
	0	less than 20%

Note: Some " reject " cream can be determined without tests. Visible mold on cream or inside of can, insects, and excessive visible extraneous matter constitute grounds for rejection.

3. Quality basis with a price differential exemplified by the Canadian Provincial Grading Laws.

The outstanding considerations in grading cream are:

1. Flavor and odor.
2. Acidity, especially above 0.6 per cent (less for rich cream).
3. Presence of yeast and gas.
4. Age.
5. Presence of insects, sediment, etc.
6. Presence of molds, especially colored molds.
7. Container; rust, open seams, type cover, etc.

The acidity basis of grading is, obviously, incomplete. It has been used because it is easy to practice. Cream may be relatively sour and make a good grade of butter.

The time basis also is incomplete. The flavor and odor of cream are much more important and are the paramount considerations in any scheme of grading. As a method of cream improvement, the "four-day plan" has value and it is not difficult to practice.

The third basis for grading, viz., "Quality with a price differential," takes into consideration most of the points listed above. It is best explained by giving the specifications of the Canadian grading laws.

The Canadian plan provides for five grades of cream, as follows:

Canadian Plan for Grading Cream

(Effective March, 1924)

Grade name	Acidity limit	Flavor description	Price differential
Table cream..	0.20 per cent	Sweet—not frozen—for household use	2 cents over No. 1
Special grade..	0.30 per cent	Clean—uniform—will make butter of this grade (special)	2 cents over No. 1
No. 1 grade...	0.60 per cent	Clean—uniform—will make butter of this grade (No. 1)	3 cents over No. 2
No. 2 grade...	none	May be bitter, stale, metallic or otherwise unclean—below No. 1 grade	
Off grade.....	none	May have kerosene, gasoline, stinkweed, onion, etc., and will not make No. 2 butter	Not specified

Government-trained graders work in creameries and are paid by the government while grading cream. When not so employed they do other creamery work and then are paid by the creamery. They are shifted from one creamery to another as directed by the provincial officer.

Here is how the compulsory grading law in Canada worked the first fourteen years after its adoption.[6]

CREAM GRADING REPORT, 1937

(D. E. MacKenzie at the Manitoba Dairy Convention, January 25, 1938
Manitoba Department of Agriculture, Dairy Branch)

Percentage of Butterfat in Each Grade

The percentages of butterfat for the *summer* season are:

	Table	Special	No. 1	No. 2	O. G.
May 1 to Oct. 31, 1923......	13 1	6.7	56.5	23.1	0.6
May 1 to Oct. 31, 1924......	18.9	6.0	59.1	15.5	.5
May 1 to Oct. 31, 1925......	20.4	6.1	53.6	19.4	.5
May 1 to Oct. 31, 1926......	23.6	6.5	52.3	17.1	.5
May 1 to Oct. 31, 1927.....	20.0	6 3	54.1	19.2	.4
May 1 to Oct. 31, 1928......	24.6	6.6	53.9	14.7	.2
May 1 to Oct. 31, 1929.....	29 6	7.2	50.3	12.7	.2
May 1 to Oct. 31, 1930......	28.9	7.5	48.8	14.5	.3
May 1 to Oct. 31, 1931......	36.1	8.7	42.0	12 9	.3
May 1 to Oct. 31, 1932......	47.0	10.4	34 5	7.9	.2
May 1 to Oct. 31, 1933......	54.1	10.4	29.8	5.6	.1
May 1 to Oct. 31, 1934......	63.0	10.5	22 1	4.3	.1
May 1 to Oct. 31, 1935......	63.2	9 8	22.7	4.1	.2
May 1 to Oct. 31, 1936......	71.1	8.9	17.0	2.9	.1
May 1 to Oct. 31, 1937......	70.9	9.5	16.8	2.7	.1

The percentages of butterfat for the *winter* season are:

	Table	Special	No. 1	No. 2	O. G.
Nov. 1, 1923 to Apr. 30, 1924.	44.4	16.1	33.7	5.5	0.3
Nov. 1, 1924 to Apr. 30, 1925.	40.9	13.5	39.4	5.9	.3
Nov. 1, 1925 to Apr. 30, 1926.	44.9	13.0	36.2	5.7	.2
Nov. 1, 1926 to Apr. 30, 1927.	51.5	12.9	31.0	4.4	.2
Nov. 1, 1927 to Apr. 30, 1928.	52.4	13.2	28.7	5.6	.1
Nov. 1, 1928 to Apr. 30, 1929.	53.3	12.6	28.7	5.3	.1
Nov. 1, 1929 to Apr. 30, 1930.	56.3	13.5	25.7	4.4	.1
Nov. 1, 1930 to Apr. 30, 1931.	62.5	11.0	22.5	3.9	.1
Nov. 1, 1931 to Apr. 30, 1932.	70.5	10.0	15.4	3.8	.3
Nov. 1, 1932 to Apr. 30, 1933.	77.9	9.8	10.5	1.7	.1
Nov. 1, 1933 to Apr. 30, 1934.	84.2	8.1	6.9	.8	.0
Nov. 1, 1934 to Apr. 30, 1935.	85.2	7.5	6.2	1.0	.1
Nov. 1, 1935 to Apr. 30, 1936.	88.5	6.2	4.7	.6	.0
Nov. 1, 1936 to Apr. 30, 1937.	87.3	6.8	5.3	.6	.0

The *yearly* percentages of butterfat received are as follows:

	Table	Special	No. 1	No. 2	O. G.
1923 (8 months)	15.1	7.4	55.1	21.8	0.6
1924	25.1	8.3	53.1	13.0	.5
1925	25.8	7.9	49.8	16.0	.5
1926	29.5	8.2	47 8	14.1	.4
1927	29.2	8.0	47.2	15.3	.3
1928	32.3	8.0	47.1	12.4	.2
1929	37.1	8.7	43.5	10 5	.2
1930	37.9	9.1	41.4	11.4	.2
1931	46.0	9.2	34 5	10 0	.3
1932	56.1	10 3	27.4	6.1	.1
1933	61.4	10.1	24 0	4.4	.1
1934	68.7	9.8	18 0	3 4	.1
1935	68.8	9.2	18.6	3.3	.1
1936	75.8	8.1	13.7	2.3	.1
1937	75.1	8.7	13.9	2 2	.1

O. G. = off grade.

It will be noted in these specifications that sediment and molds are not mentioned, but it is very likely that they are taken into account in actual grading. These two points are of vital concern in the United States because of the recent activities of the federal and state governments.

Visible mold on cream or on the inside of cans and covers is objectionable. *Oöspora lactis*, the white mold sometimes found on dairy products, is less objectionable than the colored molds, but its presence indicates that cream is very old and that very little attention has been given the cream cans. Colored mold on either the cream or the can is sufficient reason for condemning cream.

Sediment tests should be run on the cream of all patrons. Surprise tests should be made once or twice each month and, if a patron's cream is not clean, tests should be run on all deliveries until improvement is noted. He should be paid in accordance with the grade determined, and the sediment test may be the determining factor in establishing the grade.

Sediment testers are obtainable from the creamery supply houses. In addition to these, other testers, developed recently, have come to our attention.

The question of grading or rejecting cream when the amount and kind of sediment are the determining factors is difficult to decide. The Federal Pure Food Department states that "cream containing sediment in amounts and of such nature as to be considered unfit for human food by persons of acceptable standards of cleanliness shall be rejected as illegal cream."

STATE CREAM GRADING LAWS

Model Statute. A model statute was drawn up by a national creamery industry committee. This statute, submitted in December, 1934, was intended for use by state legislatures in framing state cream-grading laws. Its essential features are:

First-Grade Cream shall consist of cream that is clean and sound, smooth, free from undesirable odors and flavors, sweet or slightly sour, and shall contain not less than 25 per cent of butterfat.

Second-Grade Cream shall consist of cream that is clean and sound. It may contain some "off" flavors or odors in a moderate degree or may be too old to pass as First-Grade Cream.

Unlawful Cream shall consist of cream which contains dirt, filth, or other foreign matter which makes it unfit for human consumption; or cream that is stale, rancid, putrid, or decomposed.

Cream buyers shall affix tags to unlawful cream (tags furnished by the State Department of Agriculture). They shall also place a permanent harmless coloring matter in the cream.

The cream buyer shall ship cream within twenty-four hours to a manufacturing plant except in cases where acts of Providence interfere with compliance.

The cream buyer shall buy according to grades herein defined, shall pay at least one cent differential between contiguous grades, and shall post these prices in a prominent place where cream is bought.

At least one sediment test per month shall be run on the cream of each patron.

The state shall license a cream buyer in each place where cream is bought. The licensee shall have proved his ability to the state that he is competent to grade and test cream.

College Creamery Grades. The Dairy Department at South Dakota State College operates with the following grades and specifications:

Grade 1. Cream which will make butter of 92 score, or higher, shall be pure, fresh and clean: acidity not over 0.20 per cent, fat not less than 30 per cent, free of foreign material, a good clean cream can, not frozen, not over 60° F. when delivered, not over 2 days old in summer or 3 days old in winter.

Grade 2. Cream which will make butter of 90 score or higher: clean in flavor, not over 0.5 per cent acidity, fat not less than 25 per cent, not over 4 days old.

Grade 3. Cream which will make butter scoring less than 90: may have off flavors but not intense, no acid limit, may have some sediment. (Grade 3 is used only for instructional purposes.)

Iowa Law. The Iowa Cream-Grading Law specifies cream grades as follows:

Sweet Cream. Shall be clean to the taste and smell, and acidity not to exceed 0.2 per cent.

First-Grade Cream. Shall be clean to the taste and smell, smooth, no objectionable flavors and odors, and not more than 0.6 per cent acidity.

Second-Grade Cream. May have objectionable flavors and odors, and is too sour or too old for first-grade cream.

Unlawful Cream. Contains dirt, filth, oil, or other foreign matter making it unfit for human food; or it is stale, cheesy, rancid, putrid, decomposed, or actively foaming.

At least one cent differential in grade prices shall be paid. Harmless coloring matter shall be added by the licensed cream grader to unlawful cream.

Minnesota Law. The Minnesota Cream-Grading Law defines grades essentially the same as the Iowa law. At least one cent differential is paid and condemnation tags as well as harmless coloring matter are used for unlawful cream.

It will be noticed that the Iowa and Minnesota laws do not include statements about the grade of butter which cream will make. The grades of cream defined by the Canadian laws do refer definitely to the grade of butter which may be expected. It is true that the score of butter may be lower than expected from a certain grade of cream because of faulty manufacture or insanitary conditions in a creamery. This condition, however, is exceptional. The millers and packing houses buy on basis of grade of flour or meat expected.

It is believed that the man who knows quality in cream and butter will definitely use the grade of butter expected when he grades cream, even though the laws make no reference to it. It has been suggested that a cream-grading law is more easily enforced if no reference is made to the quality of butter which certain grades of cream should produce, because of the variable conditions of manufacture.

Oklahoma, North Dakota, Nebraska, and Washington also have cream-grading laws. All states are working for milk- and cream-quality improvement, and more intense work has been done the past three years. They operate on the basis of existent pure-food laws. The food authorities in many states have added regulations which help in the quality-improvement work.

California has been engaged in an intensive milk-and-cream grading and improvement program since 1923. Milk and cream inspectors and graders are selected on a civil-service basis and are confined to a given territory. Milk and cream buyers furnish funds to the state department of agriculture based on their volume of butterfat. These funds are used to handle the expense of inspection. All milk and cream received in each plant is graded at least once and frequently twice each week. Producers are warned and farms are visited to help in improvement. After a second warning, the producers are not allowed to sell until they have complied with the laws regulating sanitary dairies. (The program has met with satisfaction and excellent results have been obtained.)

In addition to state graders, each creamery is required to have a licensed butter grader. The butter grader also keeps a close check on cream quality as it affects the legal grade under which the creamery may sell its butter.

Survey of Cream-Grading Laws (June, 1938). A survey of the status of cream grading, made by the Olsen Publishing Company, was published June 10, 1938, in *The National Butter and Cheese Journal.* Because laws and regulations differ in the several states it is difficult to tabulate facts or figures, and reference must be made to conditions in each state. This fact limitation, together with the knowledge that this work is to a large extent in a formulative and transitional stage, indicates that a thorough and comprehensive discussion is difficult at this time. Details of the Olsen survey are given in Appendix A of this book.

Sediment Test. Sediment tests on cream are run as follows:

1. Use a clean 4-oz. jar to sample the cream when thoroughly stirred. Fill the jar full of cream, which will serve for both the fat test and the sediment test.
2. After the fat test, place the cream in the tester, add a few drops of phenolphthalein indicator, and slowly add soda ash solution (½ lb. to 1 gal. water) until a faint permanent pink color remains.
3. Add about 8 oz. of hot water. Mix well and filter.
4. Rinse the tester with hot water and force through the pad to free the pad of fat.
5. Thumb tack the pad to a card, placing an identification number under it.

Precaution. Sample jars, soda ash solution, hot water used for dilution, and the sediment tester, all must be free of sediment. Strain the soda ash solution and the hot water through clean muslin, and be sure all sediment is removed.

NOTE: Sweet cream needs no alkali. Merely dilute it with the filtered hot water.

Why Cream Tests Vary. Variations in fat tests of cream are sometimes a cause for argument, or the patron may mistrust the buyer of cream. Factors affecting tests which may help to settle these difficulties between producers and buyers are reviewed here.

1. The test of milk directly changes the fat test of the cream. A cream separator delivers a constant ratio of cream to skim milk, if conditions of separation are constant. For example, if the cream or skim milk screw is set so that the separator delivers 10 lb. of cream and 90 lb. of skim milk, the following figures explain the effect of the test of the milk on the test of the cream.

Test of Milk	Pounds Skim	Pounds Cream	Pounds Fat	Ratio	Test of Cream
4 per cent	90	10	4	4/10	40 per cent
3 per cent	90	10	3	3/10	30 per cent

Herd milk does not vary more than 0.2 to 0.5 per cent, on the average, from day to day. According to the figures above, this alone will account for a variation of 2 to 5 per cent in the cream test. For variation of fat tests of milk, see Chapter 4, "Variations of Fat in Milk and Cream."

2. The position of the skim-milk or cream screw. Turning the cream screw in produces richer cream, and vice versa. Turning the skim-milk screw in produces thinner cream.

3. Speed of the separator. The higher the speed, the richer the cream, and vice versa. The ratio of pounds of cream to pounds of skim milk is changed.

4. Rate of inflow to the bowl. Feeding more slowly produces richer cream, and vice-versa. Feeding slowly produces proportionately less cream. Feeding too fast produces more cream with a lower test.

5. Temperature of the milk. Cold milk yields richer cream. However, the skim milk will contain considerable fat.

6. Amount of skim milk or water used to flush the bowl. Greater amounts lower the test of cream.

7. Dipping cream from milk cans before separation (for household use).

Some cream producers have a mistaken notion that sour cream tests higher than sweet cream. This is erroneous. It is possible that cream kept for several days will test higher, owing to evaporation of water from the cream. The pounds of butterfat, however, will be the same. Less cream with a slightly higher test gives exactly the same total pounds of fat. By keeping cream until it sours the producer gains nothing and really loses much. The delay may result in an illegal grade of cream, owing to poor quality. Because it is more difficult to sample sour cream properly, the fat tests may be incorrect.

PRICES CREAMERIES CAN PAY FOR FAT

This section on the prices creameries can pay for fat, both the text and the table, is reprinted from the *Land O' Lakes News* for February, 1934.

> There is always going to be more or less dissension among farmers as to prices they receive for butterfat at their local

creamery and more or less misunderstanding as to why some creameries selling on exactly the same market as others can pay prices that seem out of line with possible differentials in manufacturing costs and local sales that sometimes bring a little higher price than outside sales.

It is too often the case that the same can of cream sold at two different points will bring exactly the same amount of money even though the price per pound is 2c or 3c less at one place than at another, and there are any number of instances where a farmer actually receives less for his can of cream where the highest price is paid for butterfat. By this we do not mean to infer that certain creameries cannot pay more than others, but we do, however, know that farmers often misjudge the services of their local creamery, and their lack of understanding of the factors that enter into the price paid for butterfat often creates a situation where honesty in operation is placed at a disadvantage and forces that are demanding higher prices for butterfat that are out of line with actual net prices received for butter are putting a premium on dishonesty in making tests and weights.

A table (page 97) prepared by C. W. Fryhofer, Supervising Federal-State Butter Grader, gives some very interesting material with respect to prices that can be paid on a basis of legitimate overrun.

Figures are reproduced here (pages 98, 99) through the courtesy of the Iowa Creameries Association. A detailed study of these data permits the creamery operator to compare his records and possibly find the answer to perplexing problems. The relation of cream and butterfat bought to unit manufacturing costs is particularly interesting. One difficulty is encountered here. There is a very definite lack of a uniform cost-accounting system in many states. Iowa has done much to provide such a system.

Buying Price Related to Volume. It has been observed that a creamery which produces about a million pounds of butter per year operates with the lowest manufacturing costs. (See Fig. 32.) Competition is keen enough in most districts so that procurement costs increase as volume increases. Factory personnel and factory overhead increase more rapidly with expansion beyond a medium volume. However, even though manufacturing costs increase slightly, larger creameries may still possess economic advantages because the market prefers large lots of uniform-quality butter.

PRICE A CREAMERY CAN PAY FOR BUTTERFAT

Based Upon a Uniform Standard of Composition for Butter

Moisture	Salt	Curd	Butterfat
15.8%	2.5%	1.0%	80.7%

In 100 pounds of butter of the above composition, there are 15.8 pounds of water, 2.5 pounds of salt, and 1.0 pounds of curd, or a total of 19.3 pounds which is not butterfat, known as "gain" or "overrun."

In 100 pounds of finished butter, then, there would be 19.3 pounds gain or overrun and 80.7 pounds butterfat. The per cent of overrun is obtained by dividing 19.3 pounds gain by 80.7 pounds butterfat (19.3 pounds divided by 80.7—23.9% overrun).

PRICE CREAMERY CAN PAY PER POUND BUTTERFAT

When net price received for butter is:	When Cost of Manufacture is							When net price received for butter is:	When Cost of Manufacture is						
	2c	2½c	3c	3½c	4c	4½c	5c		2c	2½c	3c	3½c	4c	4½c	5c
.16	17.3	16 7	16 1	15.4	14 8	14 2	13 6	.33½	39 0	38.4	37 7	37 1	36 5	35 9	35.3
.16½	17.9	17.3	16 7	16 1	15 4	14 8	14 2	.34	39 6	39 0	38 4	37 7	37 1	36 5	35.9
.17	18.5	17.9	17 3	16 7	16 1	15 4	14 8	.34½	40 2	39 6	39.0	38.4	37 7	37.1	36 5
.17½	19 2	18 5	17 9	17.3	16.7	16 1	15 4	.35	40 8	40 2	39 6	39 0	38.4	37.7	37.1
.18	19 8	19.2	18 5	17.9	17.3	16 7	16.1	.35½	41 5	40 8	40.2	39 6	39.0	38 4	37.7
.18½	20 4	19 8	19 2	18 5	17.9	17.3	16.7	.36	42.1	41 5	40 8	40 2	39 6	39 0	38 4
.19	21.0	20.4	19 8	19 2	18 5	17 9	17 3	.36½	42 7	42 1	41.5	40 8	40 2	39 6	39 0
.19½	21.6	21 0	20 4	19 8	19.2	18 5	17 9	.37	43 3	42.7	42 1	41 5	40 8	40 2	39 6
.20	22 3	21 6	21.0	20.4	19.8	19 2	18.5	.37½	43.9	43.3	42 7	42 1	41.5	40.8	40 2
.20½	22 9	22 3	21.6	21.0	20 4	19 8	19 2	.38	44 6	43 9	43 3	42 7	42.1	41.5	40.8
.21	23 5	22 9	22 3	21 6	21.0	20 4	19 8	.38½	45 2	44.6	43 9	43 3	42.7	42.1	41 5
.21½	24 1	23 5	22 9	22 3	21 6	21 0	20 4	.39	45 8	45 2	44 6	43 9	43 3	42 7	42.1
.22	24.7	24 1	23 5	22 9	22 3	21.6	21 0	.39½	46 4	45 8	45 2	44 6	43 9	43 3	42.7
.22½	25.4	24 7	24 1	23 5	22 9	22 3	21 6	.40	47 0	46 4	45 8	45 2	44 6	43 9	43.3
.23	26.0	25 4	24.7	24 1	23 5	22 9	22 3	.40½	47 7	47 0	46 4	45 8	45 2	44 6	43 9
.23½	26 6	26 0	25 4	24.7	24.1	23 5	22 9	.41	48 3	47.7	47 0	46 4	45.8	45 2	44.6
.24	27 2	26 6	26 0	25 4	24 7	24.1	23 5	.41½	48 9	48 3	47 7	47 0	46 4	45 8	45.2
.24½	27 8	27 2	26 6	26 0	25 4	24 7	24.1	.42	49 5	48 9	48 3	47 7	47 0	46 4	45 8
.25	28 5	27 8	27 2	26 6	26 0	25 4	24 7	42½	50 1	49 5	48 9	48 3	47 7	47 0	46 4
.25½	29 1	28.5	27 8	27 2	26 6	26 0	25 4	.43	50 7	50 1	49 5	48 9	48 3	47 7	47 0
.26	29 7	29 1	28 5	27 8	27 2	26 6	26 0	.43½	51 4	50 7	50 1	49 5	48 9	48 3	47 7
.26½	30 3	29 7	29 1	28 5	27 8	27 2	26 6	.44	52.0	51.4	50 7	50 1	49.5	48 9	48.3
.27	30 9	30 3	29 7	29 1	28 5	27 8	27.2	.44½	52 6	52 0	51 4	50 7	50.1	49 5	48 9
.27½	31 5	30 9	30 3	29 7	29 1	28 5	27 8	.45	53 2	52 6	52 0	51.4	50 7	50 1	49 5
.28	32 2	31 5	30 9	30 3	29 7	29.1	28 5	.45½	53 8	53 2	52 6	52 0	51 4	50 7	50.1
.28½	32.8	32.2	31 5	30 9	30 3	29 7	29 1	.46	54 5	53 8	53 2	52 6	52.0	51 4	50 7
.29	33.4	32 8	32 2	31 5	30 9	30 3	29 7	.46½	55 1	54 5	53 8	53 2	52 6	52.0	51 4
.29½	34 0	33.4	32 8	32 2	31 5	30 9	30 3	.47	55 7	55 1	54 5	53 8	53 2	52 6	52.0
.30	34 6	34.0	33 4	32 8	32 2	31 5	30 9	.47½	56 3	55 7	55 1	54 5	53 8	53 2	52 6
.30½	35.3	34 6	34 0	33 4	32 8	32.2	31 5	.48	56 9	56 3	55 7	55 1	54 5	53 8	53 2
.31	35 9	35 3	34 6	34 0	33 4	32.8	32 2	.48½	57 6	56 9	56 3	55.7	55 1	54 5	53.8
.31½	36 5	35 9	35.3	34 6	34 0	33 4	32 8	.49	58 2	57 6	56 9	56 3	55 7	55 1	54.5
.32	37.1	36 5	35 9	35 3	34 6	34 0	33.4	.49½	58 8	58.2	57.6	56 9	56.3	55 7	55 1
.32½	37.7	37 1	36 5	35 9	35.3	34 6	34.0	.50	59.4	58.8	58.2	57.6	56 9	56 3	55.7
.33	38 4	37 7	37 1	36.5	35 9	35 3	34.6								

The price of butter is the net price received by the creamery after freight and other marketing costs have been deducted. The cost of manufacture varies according to volume of output and varying local conditions. It will, however, average higher rather than lower than three cents per pound. The tendency in some creameries is to underrate the cost of manufacture by not including all items properly included under manufacturing cost.

When comparing prices paid for butterfat, attention should be given to the items included in the cost of manufacture, or operating cost. An overrun of 19.3 pounds, or 23.9%, is here considered as the maximum overrun any creamery could obtain on the basis of the above standard of composition and assuming that the patrons receive correct weights and tests on their cream.

C. W. FRYHOFER,
Supervising Federal-State Butter Grader.

1932 Tabulation of Reports from Local and Co-operative Creameries in Iowa

(Iowa Creameries' Association, Waterloo)

Fiscal Year Ending January 1, 1933

	Pounds Butterfat Received	Pounds Butter Manufactured	Per Cent Overrun	Av. Net Price Received per Pound Butter	Av. Price Paid per Pound Fat	Cost Manufacturing per Pound Butter
1	1,933,863.7	2,394,695	23.86	19.44	21.82	1.98
2	1,589,364	1,975,089	24.26	19.54	21.89	1.67
3	1,519,522	1,885,402	24.07	19.49	21.75	1.82
4	1,490,538.6	1,853,077	24.34	19.66	22.82	1.52
5	1,150,656.9	1,425,239	24.10	19.92	20.53	3.24
6	1,098,410.2	1,366,483	24.41	19.45	22.04	2.48
7	1,048,765	1,286,594	23.50	19.75	21.75	2.39
8	972,091	1,186,447	23.90	19.77	21.85	2.60
9	907,549	1,128,132	24.30	18.98	20.33	2.39
10	884,420.3	1,077,078	23.71	19.21	22.07	1.84
11	883,197.9	1,093,504	23.81	19.11	21.09	2.04
12	876,876	936,590	23.14	20.92	22.36	1.44
13	835,990	1,038,306	24.20	19.20	20.94	2.78
14	745,839	908,168	24.20	20.50	22.66	....
15	723,867.7	884,246	24.01	19.24	21.06	2.31
16	718,675.5	874,571	22.70	21.20	23.32	1.92
17	707,787.4	880,589	24.40	18.93	21.16	2.06
18	664,126	826,677	24.48	19.37	20.92	2.88
19	648,732	794,665	22.50	19.40	21.80	2.55
20	638,967	788,185	23.35	19.22	20.50	2.57
21	609,231	750,591	23.20	19.70	21.30	2.24
22	596,132.9	725,997	22.00	18.68	20.46	2.04
23	586,276.7	724,124	23.51	20.33	22.74	2.00
24	577,441	717,274	24.22	19.11	20.43	2.67
25	572,360	706,409	23.40	19.43	21.10	2.56
26	567,813.3	702,852	23.79	19.45	21.16	2.00
27	553,842	681,564	23.06	18.94	20.36	2.14
28	544,320	672,852	24.16	18.80	20.29	2.51
29	524,856	649,084	23.81	18.90	19.90	2.50
30	492,589	610,011	23.80	19.60	22.10	2.17
31	478,261	591,862	23.75	20.39	23.29	1.93
32	472,132	581,657	23.20	19.30	21.25	2.28
33	470,849	581,737	23.52	19.60	22.00	2.10
34	463,823	576,899	24.37	19.11	20.60	2.81
35	454,897.2	564,893	24.34	19.75	22.30	2.20
36	430,958	535,019	24.14	.....	20.53	3.35
37	420,020	519,765	23.75	19.23	19.85	3.32
38	413,170	513,645	24.32	19.97	20.42	3.21
39	408,762	508,682	24.40	19.70	21.84	2.27
40	396,586.4	493,686	24.40	18.80	20.98	2.06
41	384,305	474,775	23.54	20.15	22.40	2.00
42	371,630.4	459,143	24.20	19.64	20.67	3.41
43	369,929.5	453,566	23.50	20.00	20.59	3.71
44	366,301.3	455,674	24.39	20.05	23.13	2.11
45	358,590.6	443,482	23.94	19.38	21.75	2.58
46	353,776	438,406	23.92	19.01	19.07	3.09
47	350,458	433,808	23.78	19.19	21.33	2.00
48	346,693	428,447	23.50	19.97	21.74	2.04
49	327,580	406,674	24.11	19.33	20.50	2.57
50	319,452.4	394,872	23.70	19.17	20.36	3.50

1932 Tabulation of Reports—*Continued*

	Pounds Butterfat Received	Pounds Butter Manufactured	Per Cent Overrun	Av. Net Price Received per Pound Butter	Av. Price Paid per Pound Fat	Cost Manufacturing per Pound Butter
51	315,654	391,577	24.10	19.64	21.90	2.17
52	315,570	393,487	24.37	19.16	21.03	2.42
53	301,530	375,139	24.40	19.54	21.44	2.09
54	301,179.4	365,725	23.32	20.00	21.94	2.55
55	300,959	371,491	23.43	19.24	21.36	2.18
56	295,890	365,762	23.61	19.44	21.50	2.65
57	286,677	355,905	24.12	19.23	20.00	3.06
58	282,978	358,414	26.65	19.31	21.60	2.40
59	282,846.7	352,847	24.74	20.14	22.01	2.38
60	279,092	342,021	24.15	19.29	20.67	2.82
61	276,660	343,028	24.00	19.30	21.50	2.30
62	275,994.6	343,190	24.30	19.48	20.97	2.70
63	270,345.8	330,995	23.79	18.91	20.68	3.36
64	265,385	327,702	23.48	18.47	19.64	2.78
65	264,037.3	326,121	23.51	19.15	21.37	1.84
66	262,674	325,126	23.77	19.95	21.09	3.19
67	255,834	312,077	21.90	18.60	19.27	3.37
68	248,768	234,686	24.32	19.14	20.31	2.64
69	240,070	298,167	24.20	20.00	22.00	2.50
70	232,231	288,565	24.20	20.40	21.20	2.70
71	231,471	286,631	23.83	19.53	21.28	2.75
72	230,177	283,257	23.06	20.96	21.86	4.00
73	224,367	276,722	23.30	17.70	19.06	2.30
74	217,656	267,657	22.97	19.60	20.88	2.70
75	208,249.5	258,416	24.09	20.30	22.27	2.43
76	207,422	259,535	25.12	19.26	21.10	2.41
77	207,413	256,065	23.40	19.70	21.40	2.25
78	205,986.9	256,768	24.60	19.50	21.50	2.50
79	202,952	251,493	23.90	19.50	19.50	4.00
80	200,042	244,477	22.20	19.20	20.60	2.70
81	199,530	247,176	23.88	18.86	19.38	3.50
82	186,129.3	230,800	24.08	18.94	19.70	3.15
83	178,217	220,794	23.80	20.01	22.16	2.85
84	176,586	219,475	24.28	19.29	20.09	3.97
85	175,568.2	206,769	22.70	19.20	20.34	2.77
86	169,103.3	208,082	23.05	19.65	20.61	2.99
87	163,854	172,531	27.56	20.91	22.53	2.71
88	152,838.5	186,716	22.16	19.92	20.83	3.14
89	150,682	186,557	23.81	18.79	20.89	2.31
90	149,875	185,590	23.82	20.45	22.00	3.31
91	147,629.5	183,716	24.44	18.00	18.00	3.00
92	129,631.7	159,759	23.30	19.00	21.00	3.00
93	126,133.7	152,180	24.42	19.68	19.38	4.05
94	124,063	153,156	23.45	19.37	18.82	5.01
95	120,898	150,192	24.20	18.70	19.30	2.27
96	99,135	124,138	24.22	18.98	19.46	3.52
97	90,962.5	109,993	21.05	19.34	19.92	3.10
98	*1,618,936	2,011,023	24.40	19.43	21.44	2.03
Total	45,472,585	55,952,733	2,336.50		Weighted Averages	
Av.	464,005	570,946	23.84	19.56	21.18	2.34

* No. 98 received too late to rank. Should rank second.

Small lots of butter of variable quality always sell at a disadvantage. As proof of this, note quotations of centralized car-lot sales as compared with local creamery sales of the same grade.

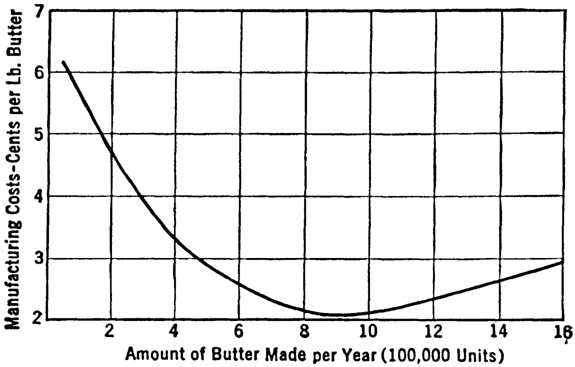

FIG. 32. Theoretical graph: relation of manufacturing costs and creamery output of butter. Increases in costs, beyond a volume of 800,000 to 1,000,000 pounds, depend on methods of accounting. Larger investments of capital for buildings and equipment and costs of cream procurement may not be included in manufacturing costs.

Tendency to Pay too Much. In scanning Fryhofer's chart, "What a Creamery Can Pay for Fat," we see that when the net price for butter is 19.5 cents, a creamery can pay 21 cents for fat when the manufacturing cost is 2.5 cents per pound. Then observe that 98 Iowa creameries paid 21.18 cents for fat and received 19.56 cents for butter and their average manufacturing cost was 2.34 cents. It appears that they paid a little too much for butterfat.

Taking the average figures for the 98 creameries we may calculate thus:

Average overrun	23.84 per cent		
Received for butter	19.56 cents		
Paid for fat	21.18 cents		
Manufacturing cost	2.34 cents		
100 lb. fat costs		$21.18	
123.84 lb. of butter × 2.34 cents (manufacturing cost)		2.89	
123.84 lb. butter sold at 19.56 cents (net)			24.22
Profit		0.15	
		$24.22	$24.22

These figures bear study and speculation. The thought to be left with the student is the fact that creameries very often pay more than a justifiable price for butterfat.

INFLUENCE OF MANUFACTURING COSTS ON BUTTERFAT PRICES*
(Calculations based on figures given in table by C. W. Fryhofer)

Net received for butter	Manufacturing Costs per Pound Butter Made 2¢	3¢	4¢	5¢
	Amount over or under which can be paid for fat and have some profit margin			
16¢	+1.3	+0.1	−1.2	−2.4
20¢	+2.3	+1.0	−0.2	−1.5
24¢	+3.2	+2.0	+0.7	−0.5
28¢	+4.2	+2.9	+1.7	+0.5
32¢	+5.1	+3.9	+2.6	+1.4
36¢	+6.1	+4.8	+3.6	+2.4
40¢	+7.0	+5 8	+4.6	+3.3
44¢	+8.0	+6.7	+5.5	+4.3
48¢	+8.9	+7.7	+6.5	+5.2

* No allowance has been made for freight on butter.

Low Manufacturing Cost as Competitive Advantage. The figures of the table above show the great importance of manufacturing costs. The creamery having a 2-cent manufacturing cost has a 3.7 buying price advantage over the creamery with a 5-cent cost. Not only this, but in the higher price range the creamery with a larger volume can shift some of its profits into higher buying prices with less strain on its financial standing, and is in an exceedingly strong competitive position. When local creameries are paying 45 cents for butterfat, direct-shipper central creameries have quoted prices 5 cents higher. The 3.7 cents price advantage, together with shifting profit to increase their butterfat price as well as their advantage in car-lot sales and direct-to-consumer sales, helps to explain what may seem to be a puzzle.

Figures are given below to show why the creamery pays more for butterfat than the market price of butter when butter prices are high. In contrast, figures are given to show a reverse condition when butter prices are low.

The figures are applicable to the same creamery and the amount of butter made is the same in both instances.

A manufacturing cost of 2½ cents per pound of butter is stipulated when butter prices are low. The assumption is that labor costs, supplies, etc., are lower. Also, with low butter prices we propose a net profit of $15.00 contrasted with a $25.00 profit when butter prices are high.

RELATION OF BUTTER PRICES, MANUFACTURING COSTS, AND CREAMERY PROFITS

50-cent market for butter $3\frac{1}{2}$-cent manufacturing costs	18-cent market for butter $2\frac{1}{2}$-cent manufacturing costs
1000 lb. butter ÷ 1.25 = 800 lb. butterfat 800 lb. fat @ 50 cents lb. = $400 1000 lb. butter × $3\frac{1}{2}$ cents = $35 manufacturing cost Freight to Chicago at $1\frac{1}{3}$ cents per lb. of butter = $13.00 $400 + $35 + $13 = $448 1000 lb. butter sold at 50 cents = $500 $500 − $448 = $52.00 net profit	1000 lb. butter ÷ 1.25 = 800 lb. fat 800 lb. fat @ 18 cents lb. = $144 1000 lb. butter × $2\frac{1}{2}$ cents = $25 manufacturing cost Freight to Chicago @ $1\frac{1}{3}$ cents per lb. of butter = $13.00 $144 + $25 + $13 = $182 1000 lb. butter sold at 18 cents = $180 $182 − $180 = $2.00 loss
Propose $25 net profit $52−$25 = $27 excess profit with which to raise the price of butterfat to the producer $\frac{2700 \text{ cents}}{800 \text{ lb. fat}} = 3\frac{1}{2}$ cents 50 cents + $3\frac{1}{2}$ cents = 53.5 cents, or producer's fair share	Propose $15.00 net profit $15 + $2 = $17, or total deficit to be eliminated by reducing the price of fat to the farmer $\frac{1700 \text{ cents}}{800 \text{ lb. fat}} = 2.12$ cents 18 cents − 2.12 cents = 15.88 cents, or producer's fair share

UTILIZATION OF WHOLE MILK IN CREAMERIES

Before the days of the farm cream separator, whole milk was delivered to skimming stations or creameries. Large power separators skimmed the milk and turned the skim milk back to the producers. A good grade of sweet cream was available for buttermaking and, even without pasteurization of the cream, a good grade of butter was made.

During the World War there was a definite trend in many sections toward the delivery of whole milk instead of farm-separated cream. High war-time prices of cheese and evaporated milk were the economic factors which forced this change. Creameries installed cheese-making equipment and made some cheese for a year or two in order to hold patrons. In some sections, this trend toward whole milk delivery continued and the creameries started the manufacture of various dairy products. In the wake of this trend, some creameries and cheese factories were closed, and some of the survivors became large diversified factories.

In the past six or eight years there has been a growing tendency to develop larger diversified plants. Several factors are operating to cause the change. Some of these are:

1. Trucks.
2. Good roads.
   a. Highways.
   b. Farm to market, or the lesser roads.
3. Demand for better and more uniform dairy products.
4. Plant sanitation requirements.
5. The ability to shift plant production to the products bringing greatest returns.
6. Developing markets for new products.
   a. Casein.
   b. Evaporated milk.
   c. Ice-cream mix.
   d. Frozen sweet cream.
7. Reduction of manufacturing costs.
8. The need for a solution to the poor-cream problem caused by farm separation of milk.

Creameries which depend on the manufacture of butter alone survive best in the less populous areas. They are not found in the city milk sheds. Cheese factories with sufficient output survive better than creameries near market milk areas. They can pay higher butterfat prices. A study of the dairy-plant map of Wisconsin shows the milk plants and their country receiving stations on the eastern border. From these to central Wisconsin we find cheese factories and condenseries. Along the Mississippi River and toward the central part of the state we find greater butter production.

Whole-Milk Buying Plans. In buying whole milk at dairy plants, two methods are usually used:

1. Straight butterfat basis for milk of any test.
2. Per hundredweight price for a specified test, usually 3.5 or 3.6 per cent with a specified amount for each 0.1 per cent above or below the standard.

Reference is not made here to the buying plans of city milk distributors who use several methods such as the "basic surplus plan," the "commodity use plan," etc.

Whole-Milk Trucking Costs. Trucking costs of milk delivery vary considerably. The usual range is between 12 and 25 cents per hundredweight.[7]

Factors which influence hauling costs are:

1. Distance.
2. Load.
3. Roads.
4. Size of herds.
5. Intensity of dairy production.
6. Cost of trucks and supplies.
7. Weather conditions.
8. Ownership of trucks.
9. Trip or mileage guarantee.
10. Efficiency of the driver.

In conclusion, it must be emphasized that the making of butter only cannot be carried on when whole milk is purchased. There must be a profitable utilization of the skim milk by the creamery. It cannot be returned profitably to the farm by trucks. We must therefore abandon the word "creamery" and substitute "dairy plant." This is intended to convey the thought that we have a factory with diversified output.

QUESTIONS

1. Name five methods of marketing cream by farmers. State some advantages and disadvantages of each.
2. List and explain the purposes of some bases for buying cream at cream stations.
3. When did farm separators come into general use?
4. State the advantages and disadvantages of farm-cream separation as compared to whole-milk delivery and factory separation.
5. State some precautions to observe in the transportation of cream to a local creamery and by rail or truck to central creameries.
6. Discuss the handling of cream to be held from Saturday until Monday.
7. List four general sources of flavors in cream. Which is most troublesome and needs constant attention?
8. Name some bases for grading cream.
9. List the points considered in a good cream-grading law. What tests are made on cream as it is graded?
10. List some factors which enable one creamery to pay more for butterfat than others.

11. About what price for fat seems to be the dividing line where most creameries pay the same for fat as they receive for butter? Why?
12. Why do creameries pay less for fat than they receive for butter when butter prices are low?

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CHAPTER 7

NEUTRALIZATION

Principles of Neutralization. Chemistry gives us a list of substances classified as bases. These are substances which are in chemical combination ready to react with acids or which, upon addition of water, readily become active. They will react with acids in very definite proportions when only the acids and bases are present in pure water. If other substances are present, such as various inorganic salts which may act as buffers, the expected completeness of definite reaction is altered.

Chemistry also classifies the great number of acids into two general classes, viz., organic and inorganic.

Practically all acids are sour to the taste. Boric acid, however, the common household eye disinfectant, is very faintly sour.

In general, all inorganic or so-called mineral acids are very sour and very fast reactors when added to bases. Also, we may say that most organic acids are not so strong and are not actually dangerous, as many mineral acids are. Organic acids have their origin mostly in plant and animal tissues, and always contain the element, carbon. The inorganic acids or mineral acids are derived largely from mineral sources. The following lists will serve to exemplify some compounds in each class.

Bases:

$Ca(OH)_2$—calcium hydroxide or calcium hydrate or milk of lime.

$Mg(OH)_2$—magnesium hydroxide or magnesium hydrate or milk of magnesia.

Na_2CO_3—sodium carbonate or soda ash.

$NaHCO_3$—sodium bicarbonate or baking soda.

NaOH—sodium hydroxide or caustic soda.

Na_3PO_4—trisodium phosphate.

Inorganic acids:

HCl—hydrochloric acid.

H_2SO_4—sulphuric acid.

HNO_3—nitric acid.

H_3BO_4—boric acid.

Organic acids:

$CH_3CH(OH)COOH$—lactic acid (the sourness in milk and cream).

CH_3COOH—acetic acid (vinegar).

$HOOC(CHOH)_2COOH$ and H_2O—tartaric acid (in grapes).

$COOHCH_2COHCOOHCH_2COOH$—citric acid or the acid in lemons.

The complexity of the organic acids stands out very noticeably in these few examples of common organic acids.

Bases are substances which contain, or are capable of forming, hydroxyl "OH" groups upon addition of water to them. The "OH" group imparts to the base its characteristic properties, such as the alkaline taste and slippery feeling in the hands.

When an acid and a base are brought together in a water solution, a chemical reaction occurs, and the original substances disappear upon complete neutralization. Usually two new substances are formed, viz., a neutral salt and water. In some instances intermediate products or additional products are formed, as when soda ash is added to hydrochloric acid. We have the formation of the neutral salt, sodium chloride, and a weak unstable organic acid (carbonic acid). This acid slowly breaks down, forming water and carbon dioxide gas.

$$Na_2CO_3 + 2HCl = 2NaCl + H_2CO_3(H_2O \text{ and } CO_2)$$

A simpler reaction is that of hydrochloric acid (HCl) and sodium hydroxide (NaOH) where only common salt and water are formed.

$$\underset{\text{hydrochloric acid}}{HCl} + \underset{\text{sodium hydroxide}}{NaOH} = \underset{\text{common salt}}{NaCl} + \underset{\text{water}}{HOH}$$

When milk of lime is used to neutralize cream, the reaction is as follows:

$$\underset{\text{milk of lime}}{Ca(OH)_2} + \underset{\text{lactic acid}}{2H \cdot C_3H_5O_3} = \underset{\text{calcium lactate}}{Ca(C_3H_5O_3)_2} + \underset{\text{water}}{2HOH}$$

Although acids and bases combine in very definite proportions in water, conditions are changed slightly when we work with milk or cream. Nevertheless, with a given base or "neutralizer," the amounts required run very regular in amount when similar conditions are maintained. The manufacturers and distributors of cream neutralizers furnish charts and directions for using their product. These directions should be followed. The manufacturers and distributors have determined the correct amounts to use in creamery practice. Nevertheless, the creamery operator should make check tests to know that the acidity is reduced to the point calculated.

History of Cream Neutralization. It is uncertain who made first practical use of alkalies to sweeten cream. In 1896 Babcock and Russell, at the Wisconsin Experiment Station, issued Bulletin 54. This bulletin explained the use of viscogen in restoring pasteurized cream to its natural consistency for city trade. Heating of cream causes some of the lime salts to settle out and disperses fat-globule clumps, thereby reducing the viscosity appreciably.

In 1901-1903 Dr. G. L. McKay[1] at Iowa State College reduced the acidity of cream. This appears to be the first attempt to neutralize cream on a commercial and experimental basis. Various sodas, lime, and precipitated chalk were used. Dr. McKay contributed the idea of using a perforated trough over the cream vat so the neutralizer solution could be added slowly.

In so far as we have records[2] neutralization of cream was first practiced commercially by the Continental Creamery Company in Topeka, Kansas. This process has been used continuously in this plant since the fall of 1902. It was not at first on a controlled basis. Not until 1905 or 1906 was it realized that low acidity reduction favored keeping quality, and 0.20 per cent was established as standard. The first incentive to sweeten sour cream with neutralizers, however, was to prevent curdling when cream was pasteurized.

In 1906 Gray and Rogers published a bulletin on fishy flavor in butter, and recognized high acidity in cream and butter as one of the contributing factors.

Public Opposition to Cream Neutralization. As the commercial practice of cream neutralization grew, there developed some opposition by health and control officials. The basis of their contention was that such practice encouraged the marketing of low-grade cream and that butter from such cream was questionable from the standpoint of health.

Reference to the creamery journals from the years 1910 to 1915 will show the reader innumerable references and papers on the subject of neutralization of cream for buttermaking. The practice was condemned from numerous standpoints and by men of prominence in the industry. It was attacked mainly because of two considerations, viz: (*a*) that of encouraging producers to hold cream before delivery and (*b*) the legality of its use.

Not only was there much opposition in the press at the time neutralization became generally practiced, but legislation was enacted in some instances.[3] The federal government at an early date ruled against the sale of butter made from neutralized cream.

In 1914 [3] Minnesota passed a law prohibiting the use of all kinds of neutralizers. New York later passed laws which prohibited or regulated the use of neutralizers. In October 1920 the Attorney General of the United States notified the Secretary of the Treasury that butter made from high-acid cream which had been neutralized would be classed as adulterated butter. In August 1921 the Attorney General issued a statement that butter made from cream neutralized with lime would not be considered adulterated. These enactments and pronouncements coincide with the period of general adoption of the practice, when any legislation against it was not enforced or was nullified. Experimental data became available from many experiment stations showing the improved flavor and keeping quality of butter made from neutralized cream.

Objections and prejudices against neutralization were gradually withdrawn and overcome, and it is today recognized as a standard procedure where sour cream is received. It might be added here that for many years the manufacturers of oleomargarine were very active in promoting unrest and agitation against the practice of neutralizing sour cream.

Composition and Properties of Neutralizers. The chemicals used for neutralizing cream are:

a. The carbonates of soda.

b. The hydrates of calcium and magnesium.

Formerly the oxides of calcium and magnesium were used by creamerymen. These were slaked with water and were therefore used in the hydrated form when added to cream. The oxides of calcium and magnesium produce heat when coming in contact with water and form a new chemical compound. The action of the oxides, as such, on cream would be too severe.

The carbonates of soda are mild alkalies when compared with other soda alkalies. The suggestion has been advanced that caustic soda be used for neutralizing high-acid cream. Caustic soda, however, is extremely severe and could be used only in very dilute solution. There is danger of undesirable effects upon the cream and the vat. Caustic soda does not cause foam on cream, an advantage which has suggested its use.

Bicarbonate of soda is rather mild in action. It is used where cream acidities are comparatively low. New Zealand and Australia use much of this milder soda.

Magnesium hydrate is quite suitable as a neutralizer. It is stronger than lime, less is required, and it would therefore be cheaper to use. However, it is too expensive if free from calcium hydrate and, since calcium and magnesium are usually found together in nature, most commercial lime neutralizers contain some magnesium. Some lime neutralizers require less than others in neutralizing cream. This is due primarily to the fact that they contain greater admixtures of magnesium hydrate.

Some of the chemical and physical properties of neutralizers have been tabulated by Walts and Libbert of the Arkansas station. Their data are reproduced with permission. (See pages 111-112.)

Reasons for Neutralizing Sour Cream:

1. To improve the keeping quality of butter.
2. To improve butter flavor.
3. To prevent excessive fat losses in the buttermilk.
4. To make butter of a more uniform quality.

Improvement of Keeping Quality. Pasteurized-cream butter made from sweet cream has excellent keeping quality when properly made, packed, and refrigerated. High acid in cream and in butter has been definitely proved to be injurious to keeping quality. It is this fact which has caused the creameryman to adopt neutralization of sour cream as standard practice. Acidity in butter has an ac-

Analyses of the Various Neutralizers

(Walts and Libbert, Arkansas Agricultural Experiment Station, Bull. 249, 1930)

Name of neutralizer	Total calcium as calcium oxide	Magnesium oxide	Sodium bicarbonate	Sodium carbonate	Calcium carbonate	Metallic oxides †	Silicon dioxide	Sulphur trioxide	Loss on ignition	Fineness: Through 100 mesh	Fineness: Through 200 mesh
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Peerless Neutralizer Lime	72.78	0.38	.....	.....	3 94	0 57	0.72	0 47	24 37	99 86	99.42
Neutralene	.....	.....	45.14	46.59	.....	...	...	.....	29.75	95.00	43.00
Allwood's Milk of Magnesia	55.02	39.02	....	....	3.79	0.69	0 40	0.20	4 70	81.40	76.62
Neutrazone	.....	.....	34.51	63 82	.....	....	.....	.....	24 50	83.50	60.00
Perfection C. & M. Acid Reducing Agent	45.92	32.65	.....	.....	5.66	0.53	1.29	0.66	18 40	99.87	99.24
Cream Acidity Standardizer	.....	.....	35.05	50 95	.....	.....	.....	.....	23 90	88.00	59.50
Calcium hydrate (tech.)	76.06	18.80	.....	..	*	1 13	*	*	34 90	99 50	98.00
Wyandotte	....	.....	17.17	80 12	.....	.....	.....	.....	27 00	93 50	52 50
Calcium oxide (tech.)	48.09	24.20	.....	....	*	5.97	*	*	5 41	98 00	95.50
Sodium Monohydrate (soda ash)	....	...	0 20	85 37	.....	.....	.....	.....	22 88	45 00	13.20
Sodium bicarbonate	.....	....	99 81	0 10	...	.....	.....	.....	38 49	100 00	82.50

† Chiefly iron and aluminum oxides.

* Not analyzed.

SOLUBILITY AND ALKALINITY OF THE VARIOUS NEUTRALIZERS *

(Walts and Libbert, Arkansas Agricultural Experiment Station, Bull. 249, 1930)

Name of neutralizer	Soluble material	Alkali in terms of 100 per cent for pure $Ca(OH)_2$
	per cent	per cent
Peerless Neutralizer Lime	99.50	91.30
Neutralene	100.00	48.53
Allwood's Milk of Magnesia	98 32	146.69
Neutrazone	100.00	51.56
Perfection C. & M. Acid Reducing Agent	98.30	111.20
Cream Acidity Standardizer	100 00	52.59
Calcium hydrate (tech.)	99.26	117.10
Wyandotte	100.00	53.50
Calcium oxide (tech.)	97.30	119.83
Sodium Monohydrate (soda ash)	100.00	54.94
Sodium bicarbonate	100.00	43.14

* Data represent averages from duplicate determinations on one or more samples.

celerating action on flavor deterioration. Sommer and Smit [4] show this quite conclusively. One of the most notable defects caused by high acid is fishiness. Other factors contributing to the development of fishy flavor are discussed in Chapter 9, "Starters and Cream Ripening." Since much butter must go into storage for economic and price stabilization purposes, we readily realize the need of reducing the acid in cream. Even though most butter does not go into storage, there is still a definite need for keeping quality. Butter produced in surplus producing areas must be transported to the market centers and later finds its way into retail stores and into the home. Butter is often subjected to various unsatisfactory temperatures while en route and while in the household icebox. The need of keeping quality is evident.

Improvement of Flavor. Butter made from cream with appreciable acidity is inclined to be coarse in flavor. Usually, the souring of cream is accompanied by the development of some undesirable flavors and odors. Neutralization of cream tends to reduce the intensity of these flavors and particularly so when followed by proper pasteurization. Pasteurization is also standard practice and is quite universally done even without legal requirements.

Avoiding Excessive Fat Losses. Cream containing 0.30 per cent, or more, of acid will curdle some when heated to pasteurizing temperatures. The curdling is in direct ratio to the amount of acid in the serum of cream. When curd is formed, butterfat globules are enclosed in the curd particles and pass out with the buttermilk. Therefore, sour cream must be neutralized to prevent excessive fat losses.

Uniform Quality in Butter. It is definitely advantageous to the central market operators to receive butter of uniform quality. Sales are more readily made and customers are easily retained, thus reducing the expenses of selling. The acidity of cream varies some from day to day in any plant. It may vary widely from month to month and even more at various seasons of the year. The logical conclusion is that cream should be neutralized to a rather uniform point of acidity in order to make butter of uniform quality. A reduction of acidity to 0.25 per cent has long been considered safe and practical. A number of creameries are reducing to lower points at present but they do so under well-controlled conditions and in many cases they follow the process by adding starter to cream which raises the acidity. Overneutralization is most certainly to be avoided as it produces serious flavor defects. Reducing acidity below 0.20 to 0.25 per cent should be done only with a full realization of the detrimental effects of over-neutralization.

Directions should always be obtained from the manufacturer or dealer in order to know the proper amounts of his product to use. When buying from dealers or jobbers, always learn whose product they send and be sure they give the correct figures on the use of the particular product.

It is therefore obvious that the creamery operator should always order a particular brand of neutralizer. A reliable dealer should always notify the buyer if a shipment of a different brand is made. Every creamery operator should use the utmost care to see that acidity tests are made correctly, and according to standard practices. He naturally, therefore, cannot afford to have faulty results because of using a neutralizer that will not do the work expected.

Comparison of Sodas and Limes. The use of lime as a neutralizer has an advantage from the economic viewpoint. It is an efficient neutralizer and is cheaper to use than sodas. Its cost per pound is greater, but its comparative cheapness lies in the fact that much less of it is required for a given amount of cream or lactic acid. The following comparative figures are based on chemical formulas, which of course imply chemically pure compounds.

LIMES AND SODAS COMPARED AS TO EFFICIENCY AND COST

Chemical formula	Commercial name	Pound of neutralizer needed to neutralize 1 lb. of lactic acid	Approximate cost per hundred weight of commercial neutralizer	Comparative value compared with milk of lime at $6 per hundred weight	Actual cost or neutralizing value per hundred weight
$Ca(OH)_2$.	Milk of lime or lime hydrate	0 411	$6.00	$6.00	$6.00
Na_2CO_3. .	Soda ash	0.588	6 00	4 20	8 58
$NaHCO_3$.	Bicarbonate of soda or baking soda	0 933	6 00	2 60	13 62

NOTE: Literature occasionally makes reference to sodium sesqui-carbonate. Its chemical formula is $Na_3H(CO_3)_2 \cdot 2H_2O$. It may be a product formed by evaporation of solutions containing both Na_2CO_3 and $NaHCO_3$.

0.411 : 0.588 as $6.00 : X
X = $8.58 or cost of soda as compared to $6.00 lime
0.411 : 0.933 as $6.00 : X
X = $13.62, or cost of bicarbonate of soda compared to $6.00 lime

ADVANTAGES AND DISADVANTAGES OF SODAS AND LIMES

SODAS

Advantages

1. Highly soluble.
2. Quickly soluble.
3. Does not cause cream to thicken and thus make filtering difficult.
4. Evolves CO_2 gas which tends to aerate cream with possible flavor improvement.
5. Reacts promptly.
6. Is 100 per cent efficient (except when acidity is reduced below points commonly used).

Disadvantages

1. More expensive on basis of strength.
2. Causes CO_2 gas and foam—vats cannot be full.
3. Stock solutions cannot be kept in metal containers.

Limes

Advantages	*Disadvantages*
1. Cheaper to use.	1. Slow reactor.
2. Does not cause foam.	2. Causes difficult filtering.
3. Stock mixes may be kept in metal containers.	3. Low solubility.
	4. May have clay and metallic impurities.
	5. Only 85 to 90 per cent efficient.

Logically, the use of neutralizers should not meet with objections. The products resulting from the chemical reaction are very largely carried away with the buttermilk and the wash water. Our food laws make no reference to the use of alkalies in lowering acidity in cream which is used in the manufacture of butter.

Acidity and Cream Quality. Several states have laws limiting the degree of sourness in cream for buttermaking. Some of these laws have been in existence for many years but for the most part have been neglected. During the past two years several states are enforcing new laws which draw the line between No. 1 cream and No. 2 cream at 0.60 per cent acidity. This will be further discussed under cream grading. It is desired here to leave the thought with cream buyers that acidity of cream as a single factor in cream quality is not the most important consideration. Clean sour cream may make a very suitable grade of butter when processed properly. The use of the acidity test in grading cream is based on the logical assumption that the degree of sourness of cream indicates to a considerable extent how many days and at what temperature the cream has been held.

Acidity Reduction Due to Heat. There is some reduction of acidity in cream which is due to the heat of pasteurization. This reduction is due primarily to the driving out of carbon dioxide gas from the hot cream. The gas expands, and the hot cream has less viscosity, which permits the gases to escape. In cream of moderate sourness the amount of reduction from mere heat is rather negligible. In high-acid cream, a reduction of acidity somewhat lower than the calculated may occur. Some allowance must be made for this, and again the experience of a careful operator is a most valuable asset. Such an operator will be able to judge from the acidity and condition of the cream being processed what would be a reasonable allowance. Making allowances, however, may lead to appreciable inaccuracies. It is safer to heat the test sample of gassy cream to about 150° F. at the same time the acid test is made. This heat will expel most of the gas.

Choice of a Neutralizer. There are no complete data available indicating that a better grade of butter can be made when a particular neutralizer is used, although Stiritz and Ruehe[5] have indicated that bicarbonate of soda, or baking soda, quite consistently produced butter which scored less while fresh and during the early stages of storage. They also indicated that soda ash seemed to produce butter which degraded faster during the latter part of the storage period. Both limes and bicarbonate of soda gave more exhaustive churnings than soda ash, and lime in particular aided more exhaustive churning. They stated further that neutralizers should not be mixed and then added to the cream but that each chemical compound should be added separately and that even when added separately, as in so-called "double neutralization," the effects on the quality of butter were more detrimental than when one alone was used. Walts and Libbert[6] found no significant difference in the scores of butter either fresh or stored when various neutralizers were used. Jackson[7] found lime neutralizers to produce better-flavored butter, soda compounds tending to produce bitter soapy flavors. (*Note:* Considerable interest is developing at present (1939) in the iron and aluminum content of lime neutralizers because of the probable influence of these catalysts on butter flavors.)

In commercial practice in the Middle West, considerable divergence of opinion exists. Many creameries seem to use commercial soda mixtures with entire satisfaction. A survey in South Dakota in 1927 indicated that about 50 per cent of the creameries were using commercial soda neutralizers and, when high acidity was encountered, they resorted first to the use of lime, then sodas. After trying two or three commercial soda neutralizers an operator would decide that one brand was quite superior to others. Another operator would choose a brand which was declared quite unsuitable by the first creameryman. It is unlikely that any one brand is far superior to another, since they are mostly made of different proportions of soda ash and baking soda. Walts and Libbert,[6] of the Arkansas Station, give the composition of most of the common commercial neutralizers. The mixtures of sodas may be varied in proportion at the will of the manufacturer, and the limes may vary in strength and admixture with magnesia, depending upon the brand used.

The operator should be advised by the manufacturer as to the correct amount to use and then should determine for himself, with correct acidity tests, just the proper amount.

Neutralization of Sour Cream to Prevent Fat Losses in Buttermilk. If an attempt be made to pasteurize cream which is much above 0.30 per cent in acidity, the butterfat losses in the buttermilk will increase. The careful operator will always check on fat losses in the buttermilk. Casein, in the presence of acid, coagulates when heat is applied as in pasteurization. These particles of curd hold enclosed in their meshes a certain amount of fat which is carried with the casein into the buttermilk.

The Acidity Test. In making acidity tests the acidity of the milk or cream is reduced to the neutral point for the particular indicator used, and for all practical purposes in dairy work is sufficiently accurate. However, absolute neutrality is not definitely attained as in simple solutions of pure acids and pure bases, and for two reasons, viz.:

a. The end point or change in color varies with the particular indicator used.

b. In milk and cream and other dairy products or by-products the presence of so-called "buffer substances" delays the arrival at the point of definite neutrality.

As proof of (*b*) note the first appearance of the faint pink color and, after a few seconds, its fading. Additional alkali solution is required to produce a permanent pink color. In making acidity tests, directions are given indicating that the test should be read when a pink color is attained which remains for about one-half minute. The "buffer substances" referred to consist of casein and the salts of milk. Casein is a very complex organic compound belonging to the general group of food substances called proteins. It is amphoteric in reaction, i.e., it has the property of acting both as a base and an acid although it functions to a greater extent as an acid as the neutral point is approached.

The citrates and phosphates of milk also play a considerable part in interference with a sharp and definite neutral point.[8] The latter is present in milk largely as compounds of calcium and since calcium phosphate may be present as primary, secondary or tertiary compounds it is therefore readily understood from a chemical viewpoint how it can delay the arrival at the end point in going from an acid to a basic reaction or vice versa. Sommer and Menos [9] indicate also that in titrating milk under dilutions there is a "protein effect" on the indicator.

Ripening Low-Grade Cream. When high-acid and fermented cream is reduced to 0.25 per cent acidity it cannot be ripened back to such a degree of acidity as can cream of good quality. Investigation has not definitely revealed the reasons for this although it is generally agreed that there are many by-products of bacterial action other than lactic acid which are present in miscellaneously fermented cream. These substances, probably mostly forms of protein decomposition, are not removed by neutralization and pasteurization and remain to give the cream a foreign flavor and aroma. When the attempt is made to ripen this neutralized cream back to an appreciable degree of acidity these off flavors are intensified and the butter made from such cream is of lower quality. Its keeping quality is impaired in quite direct proportion to the extent of ripening if acidity is raised above 0.28 to 0.30 per cent. This does not mean that the influence of a good starter is detrimental to such cream. On the contrary, very desirable results may be, and are, obtained in practical operation. It is believed, however, that the most judicious manner of using the starter is to add it to the cream at a low temperature, in fact too low to permit of any appreciable amount of ripening, and to use it for the purpose of having the desirable flavor of the starter submerge so far as possible any unclean or undesirable flavors that may be present. In using starter as here indicated, may it be suggested that the starter can be used by placing it directly in the churn with the cream or by dumping it into the cream vat even as much as an hour or two before churning, provided the cream is maintained at a low temperature. Attention must be directed here to the necessity of agitating the starter well before use and of straining carefully to prevent curd lumps from getting into the cream, as they may be incorporated into the butter as white specks.

Making the Acidity Test. To get the best results from neutralization the operator should first of all use great care in making acidity tests. If he is not sure of the strength of the $N/10$ alkali solution, he should have it checked or should discard it entirely, replacing it with one which is known to be correct.

Weigh 9 grams of cream into a white cup or cream test bottle. Add 3 to 4 drops of indicator and then run in the neutralizing solution $N/10$ sodium hydroxide, until a faint pink color is evident for about one-half minute. Read the burette, and each cubic centimeter of the alkaline solution represents 0.10 per cent acidity.

Many creameries use 9 cc. of cream, milk, buttermilk, etc., as a sample to test for acidity. With cream, particularly, this practice is less accurate. The specific gravity of cream varies considerably for two reasons, viz.:

1. Its fat content varies greatly; the richer it is the lighter, and vice versa.
2. The cream may be fermented and contain much gas; 9 cubic centimeters of such cream would weigh considerably less than 9 grams.

In creamery practice, the use of the 9 cc. pipette may be defended on the basis of time consumed in weighing, particularly with relatively fluid products such as sweet fresh cream, milk, buttermilk, etc. However, with cream, pipetting cannot be recommended.

Formula for Computing Acidity. The basis of the acidity test is as follows:

$$\underset{\text{sodium hydroxide}}{NaOH} + \underset{\text{lactic acid}}{H\cdot C_3H_5O_3} = \underset{\text{sodium lactate}}{NaC_3H_5O_3} + \underset{\text{water}}{HOH}$$

40 (Molecular weight) 90 (Molecular weight)

The molecular or group weights are 40 and 90, respectively, of sodium hydroxide and lactic acid. Normal solutions of each will have their respective molecular weights in grams in each 1000 cc. A tenth normal solution of sodium hydroxide is used to make the acidity test. Therefore each 1000 cc. will have 4 grams of pure

NaOH. Each cubic centimeter of this solution will have 4/1000 or 0.004 gram of NaOH.

This amount will react with 0.009 gram of lactic acid on the basis of the 40 to 90 ratio. Hence the following formula for computing acidity:

$$\frac{\text{Cubic centimeters of } N/10 \text{ NaOH} \times 0.009}{\text{Grams of sample used}} \times 100 = \text{per cent acidity}$$

Obviously now, if we use a 9-gram sample to make the test, cancellation is possible, and the formula becomes (supposition, 4.3 cc. of $N/10$ NaOH used)

$$\frac{4.3 \times \overset{.001}{\cancel{0.009}}}{\underset{1}{\cancel{9}}} = 0.0043$$

Then

$$0.0043 \times 100 = 0.43 \text{ per cent acid}$$

Indicators for the Acidity Test. An indicator is a substance which changes color at a point where all base and all acid have reacted to form a salt and water, or where basic and acidic properties are at equilibrium. There are several dozen indicators used in chemistry. They vary slightly in their sensitiveness to indicate the point of exact neutrality. Some indicate neutrality when the solution is slightly on the acid side; others indicate neutrality when the solution is slightly on the basic side of absolute neutrality.

Phenolphthalein is the common indicator used in dairy work. It indicates neutrality when the solution is slightly on the basic side but so slight as to be of no appreciable significance in practical applications. It has a red color in alkaline solution and is colorless in acid solution. It is selected because of the bright pink color it forms in alkaline solution. This is readily observed on contrast with the whiteness of milk and cream.

Phenolphthalein is an organic compound in the form of white crystals. It is dissolved in alcohol at the rate of 1 gram per 100 cc. of 90 per cent alcohol with 100 cc. of distilled water, making a total volume of 200 cc.

Some factors which have a bearing on the establishment of a point to which to reduce cream acidity are:

1. The extent of yeastiness and gassiness of cream of low grade (acid reduction due to heat.)
2. Acids other than lactic acid in poor cream such as acetic, succinic, propionic, etc.
3. Difficulty in titrating cream to the same shade of pink in making the acidity test (human eye sight, use of natural or artificial light, etc.).
4. When cream is graded and No. 1 and No. 2 cream are conducted from the weigh can to separate vats, the operator fills a vat to a certain level. He has established the fact that there are an approximate number of pounds of cream when the vat is filled to this point. The actual weight of cream may vary 50 to 75 lb. from the weight presumed.
5. Mistakes in marking the intake record to show where the cut off was made for each churning. Sales of sweet cream may be overlooked and not subtracted from the weights used in neutralizing.
6. Errors and carelessness in making and measuring stock neutralizer mixes or solutions.
7. Hardening of lime and attachment to the walls of the container when stock mixes are used.
8. Too rapid addition of the neutralizer; use of mixes or solutions of neutralizer not sufficiently diluted.
9. Interference of buffer salts in high-acid cream formed by neutralizers and lactic acid and particularly so when neutralization is carried below 0.20 per cent. Interference of these buffers when checking the churning acidity of cream.
10. Pipetting of cream for the acidity test instead of weighing the sample.
11. Whether or not starter is to be used after neutralizing, slightly lower acidities may be attained if starter is used.
12. Is the decinormal alkali solution for the acidity test correct? (weakened by age.)
13. How many drops of phenolphthalein are used in making the acidity test and what was the concentration of the indicator solution?

Obviously many of these considerations can easily be controlled by a careful workman. Such an operator can safely reduce the acidity of high-acid cream to 0.20 to 0.25 per cent. He can reduce the acidity of low-acid cream to 0.16 to 0.20 per cent. The churning acidity must be taken and recorded to enable the operator to know the efficiency of his work.

Outline of Procedure in Neutralizing a Vat of Cream:

1. Ascertain definitely the pounds of cream to be handled.
2. Agitate the cream and warm to 80 to 90° F.
3. Weigh 9 grams of cream and make an acidity test.
4. Measure the amount of stock neutralizer solution required and dilute to a 10 per cent mixture or solution.
5. Apply the neutralizer slowly either with a garden sprinkler can or through perforated drip pipes or troughs. *This is important.* Agitate cream continuously while heating, holding, and cooling.
6. Heat to 150° to 160° F., depending on grade of cream, and hold for one-half hour.
7. Except in the flush type vat outlet, draw a pail or two of cream and pour back into the vat just after the maximum temperature is reached.
8. Cool without delay to churning temperature or below and hold for two hours before churning.

Precautions:

1. Have the stock solutions of neutralizers covered except when in use. This prevents evaporation and concentration of the solution.
2. Always have stock lime mixtures completely agitated so that each unit of volume carries its proper amount of lime.
3. Stock soda solutions should never be held in metal containers. They attack the metal, and the neutralizer will carry metallic salts into the cream.
4. Stock lime mixtures can be held in metal containers because the metal very soon becomes coated with the lime. If lime mixtures are held too long this deposition of lime may account for some disappointments in acid reduction in cream because of loss of strength.

5. When using two neutralizers, as in double neutralization, add the diluted lime mixture first. Its reaction tends to be more complete owing to the greater amount of acid present. Follow with the soda neutralizer.
6. If it is planned to filter the hot cream through cloth filters it may be necessary to alter the procedure.
   a. The cream may be neutralized with either lime or soda, or both, and filtered at 90° F. temperature before pasteurization.
   b. It may be necessary to use soda neutralizers only in order to avoid the clotting effect of lime and casein when the cream is heated to pasteurizing temperature before filtering. This may be very troublesome with high-acid cream and excessive amounts of foam.

Adding the Neutralizer. The manner of application of the neutralizer is exceedingly important. It is undoubtedly more important than the kind or kinds of neutralizer used. The cream should be warmed to 75 to 90° F. when the acidity test is taken because at this point the cream is much less viscous and a more representative sample can be secured. This is very important. After calculations, or readings, from the neutralizer chart have been made, the required amount should be properly diluted as previously described. Add the neutralizer very slowly and throughout the entire length of the vat. A common garden sprinkler can is most commonly used.

A concentration of about 10 per cent is satisfactory. Fifteen per cent solutions of weaker sodas, as bicarbonates, may be used. It has been reported that some creameries use limited amounts of neutralizers consisting of half caustic (NaOH) and half soda ash (Na_2CO_3). On high-acid cream such a neutralizer would reduce gas formation. Its use is questionable because of its exceptional strength. A 3 per cent solution would be sufficiently strong. The use of such strong neutralizers is not safe in the hands of unskilled workers. Undesirable effects may be noticeable on the flavor of the cream and on the flavor and body of the butter. Even the metal of the vat may be injured. Common methods of application of neutralizers to cream do not permit sufficiently rapid mixing of the solution with the cream.

Adding the neutralizer rapidly and raising the temperature simultaneously may have the effect of partial saponification of butterfat and of tending to cause the neutralizer to be adsorbed by the protein material of the cream, thereby affecting the constancy and the completeness of reduction of acid to the point calculated. Observations have been made indicating that milk of lime is about 85 to 90 per cent efficient in reducing acidity, whereas the soda neutralizers are 100 per cent efficient in most instances. It is believed that with slower application of lime the efficiency percentage would run higher. Much lime, settled out in the bottom of the forewarmer or the cream vat, indicates that the lime has been added too rapidly.

A check for the efficiency of neutralization cannot be made until the cream has been pasteurized and is being cooled down. This fact is due partly to the presence of carbon dioxide in the cream, particularly so when soda neutralizers are used and large amounts of carbon dioxide are produced, causing foam on the cream. Carbon dioxide with the water in the cream forms carbonic acid, which obviously interferes with a check test for acid reduction. When lime is used as the neutralizer it is possible that part of it is held by adsorption, or is actually bound to the casein at high temperatures and is slowly released as temperatures are reduced. It may also settle out slightly as insoluble tricalcium phosphate since the calcium phosphates are less soluble at high temperatures. A combination of factors, therefore, is no doubt responsible for the delay in chemical equilibrium and the necessity of waiting until the cream is cooled again to get a dependable check for acidity reduction.

Preparing Stock Neutralizers for Use:

1. Use a lime which is finely pulverized, since lime is largely a suspension and not a solution. The smaller the particles, the more promptly and completely it will react.
2. Use hot water and bring to a boil with steam. The heat or agitation with steam seems to provide a smoother mix, and there is less probability of having lime settle to the bottom of the vat. Complete the total volume of mixture, after cooling, by the addition of water.

Use of Forewarmers. Many of the larger creameries use forewarmers for neutralizing cream. They can work on the volume-acidity basis, i.e., the forewarmer is filled to a definite predetermined point which represents, quite definitely, a certain number of pounds of cream. The acid test is run, and from a chart the operator determines the number of quarts or gallons of neutralizer to be used, depending, of course, on two factors: (1) kind and strength of neutralizer; (2) pounds of cream and extent of neutralization.

As one forewarmer is used for neutralizing, the second is receiving its load of cream. This procedure is followed as long as cream is received in large enough quantities to keep the intake crew working without loss of time. Since the acidity of each lot of cream varies, it is impossible to neutralize satisfactorily in continuous operation. Batches of cream must be handled separately.

The smaller creameries handle the cream in the cream vat proper for all processes up to churning. The expense of extra equipment for neutralizing, pasteurizing, and cooling is not justified, and the additional floor space needed is not available. No doubt the life and efficiency of cream vats are reduced by this multiplicity of service and alternate heating and cooling in the same vat tends to the formation of considerable scale on the inside of the coil. It is entirely possible also that these changes in temperature may affect the electric charges and difference in potential between the molecules of the different metals, particularly in plated materials, and that the cream in the vat serving as an electrolyte may cause a corrosive action. It is probable that corrosion takes place where the tin is thinnest. A heavy uniform layer of tin would decrease the tendency to corrode. Cream vats in transit for some time, subjected to marked changes in temperature, collect drops of water on the inside and have been known to develop numerous small dark corroded spots. Again the presence of an electrolyte (water containing dissolved metallic ions) and probable differences in potential are responsible for the corrosion which takes place.

Commercial Neutralizing Practices. O. F. Hunziker[10] states that, although neutralizers are foreign to cream and butter, it is nevertheless wholly advisable to reduce cream acidity. The excessive use of neutralizers is harmful because of the disagreeable flavor often left in the butter. With cream of moderate acidity there is very little choice between lime and soda neutralizers. With high-acid cream, however, the use of either one for total reduction of the acidity may, and frequently does, cause neutralizer flavor in the butter. Using lime to reduce to medium acidity and finishing with soda seems most desirable. This is referred to, usually, as double neutralization.

Mr. Dobbie of Armour and Company [10] favors the use of both lime and soda. He advises the use of dilute solutions, spraying or dripping the solution into the cream with a perforated trough.

The Harding Creamery Company [10] of Kansas City advises the use of neutralizers as follows:

Cream Acidity	*Neutralizers*
Under 0.40 per cent	Milk of lime only
0.40 to 0.60 per cent	⅔ lime and ⅓ soda
0.60 per cent and above	½ lime and ½ soda

The proportions of lime and soda are approximate. Correct amounts must be figured according to instructions given later in this chapter.

Professor Bouska,[11] technician for the Beatrice Creamery Company of Chicago, suggests a reduction to 0.25 per cent acidity in the

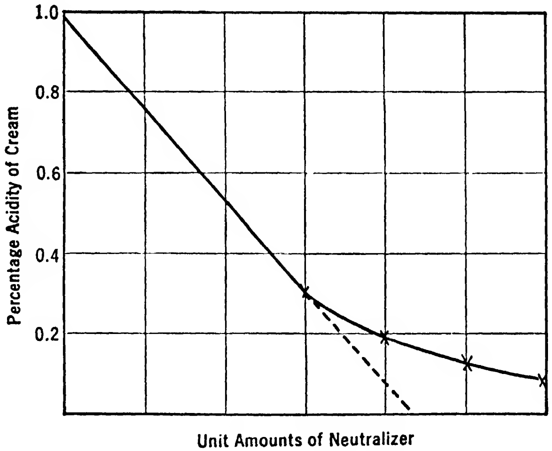

FIG. 33. Theoretical graph representing the $Ca(OH)_2$ binding power of casein. Note the quite constant reduction in acidity until a point near 0.25 per cent. From this point, we observe less acid reduction with increased addition of units of milk of lime. At lower acidities the casein starts combination with lime.

winter, using lime only. In the summer a reduction to 0.30 to 0.35 per cent acidity with lime, finishing with soda, is suggested. Both soda and lime leave distinctive flavors if used too freely.

Limes are about 85 to 90 per cent efficient in cream-acidity reduction. That is, 10 to 15 per cent more lime is required than is calculated on the basis of chemical reactions. This difference is due to the base-binding power of casein in the cream and to the particular affinity of lime and casein. It is illustrated by the accompanying graph (Fig. 33).

Acidity Reduction Due to Heat. The neutralizing power of various neutralizers is determined by the extent of acid reduction in cream. In checking their efficiency several factors enter which affect the accuracy of determinations. These are:

1. The kind of neutralizer.
   a. Whether a carbonate or a hydrate.
   b. Its solubility.
   c. The fineness of pulverization in calcium and magnesium limes.
2. The temperature attained during pasteurization, and the time it is maintained.
3. The original acidity of the cream.
4. The point to which the acidity is reduced.
5. The amount of carbon dioxide in the cream, as in the case of yeasty cream.

If cream contains appreciable quantities of carbon dioxide that are due to fermentation, it is more difficult to determine a definite end point in making an acid test. This may cause some disappointment in reaching a definite acidity reduction when cream is neutralized and pasteurized. Results may be lower or higher than calculated, depending upon the intensity of the pink color secured in the titration.

The heat of pasteurization drives carbon dioxide from the cream, and the acidity reduction due to this factor may be as much as 0.10 per cent. Usually the reduction is less than 0.05 per cent with average cream which has not developed yeasty fermentation.

It is pointed out elsewhere in this chapter that, if cream is suspected of being gassy, the sample should be heated as the acidity test is being made. Do not heat it much before starting the titration, as severe curdling may occur and delay completion of the test.

CALCULATIONS IN CREAM NEUTRALIZATION

Problem 1—Using Soda

Suppose we have a 300-gal. vat of cream. Three hundred gallons, estimating 8.3 lb. per gallon, weigh 2490 lb. (NOTE: Use the intake records preferably to have the exact number of pounds of cream). The acid test reveals 0.60 per cent acidity. We decide to use a soda neutralizer only. Its strength is such that 0.8 lb. will neutralize 1 lb. of lactic acid, or 1.0 lb. will neutralize 1.25 lb. of lactic acid. We wish to reduce the cream acidity to 0.25 per cent.

0.60 per cent — 0.25 per cent = 0.35 per cent of acid to be reduced

2490 lb. $\times$ 0.0035 = 8.71 lb. of lactic acid

Then $0.8 : 1 :: X : 8.71$

$1X = 0.8 \times 8.71$

$X = 6.97$ lb. of soda neutralizer (dry soda)

To this amount of soda we add 9 gal. of water and allow time for solution. This gives a solution which is less than 10 per cent in strength (not stronger than 10 per cent is a good rule). Apply as previously described.

Problem 2—Using Lime

Use the figures of Problem 1: 2490 lb. of cream; 0.60 per cent acidity minus 0.25 per cent equals 0.35 per cent of acid to be reduced. Use lime having a factor of 0.440. That is, 0.44 lb. of this particular lime will neutralize 1 lb. of lactic acid, or 1.0 lb. lime will neutralize 2.26 lb. of lactic acid.

2490 lb. cream $\times$ 0.0035 = 8.71 lb. lactic acid to be re-reduced

Then $0.44 : 1 :: X : 8.71$

$1X = 0.440 \times 8.71$

$X = 3.48$ lb. of dry lime needed

Instead of a ratio as above, we may use a simple multiplication:

8.71 $\times$ 0.44 = 3.48 lb. dry lime

Problem No. 3—Double Neutralization

We have 2490 lb. of cream with an acidity of 0.92 per cent. Let us neutralize to 0.40 per cent with lime, and finish to 0.25 per cent with soda.

We shall use the particular lime and soda used in the first two problems.

Calculating the Lime

0.92% — 0.40% = 0.52%
2490 × 0.0052 = 12.948 lb. acid
12.948 × 0.44 = 5.179 lb. lime
Mix with 5 gallons of water before using.

The lime is to be added to the cream first before adding the soda solution.

Calculating the Soda

0.40% — 0.25% = 0.15%
2490 × 0.0015 = 3.73 lb. acid
3.73 × 0.8 = 3.0 lb. of the soda previously used. Dissolve in about 3.5 gal. of water before use.

Allow a 5- to 10-min. interval.

Stock Lime Mix Preparation

Now let us prepare a stock lime mix and use it to neutralize the same vat of cream.

Place 20 lb. of dry lime in a 10-gal. can. Add hot water, and inject steam until it reaches a boil. Allow to cool, and then fill the can to the 10-gal. volume. Each pint of this mix contains 0.25 lb. of lime (when completely stirred before use). 3.48 lb. of dry lime were required for Problem 2. 3.48 divided by 0.25 equals 13.92 pt. of stock mix. This amount must have 13.92 pt. of water added to it before use so it will not have over 10 per cent strength. Stock lime mix may be stored in metal containers other than galvanized ones.

Stock Soda Neutralizer Solution

Dissolve 20 lb. of neutralizer in cold water, and fill to a volume of 10-gal. This solution will contain 0.25 lb. of neutralizer per pint.

10 gal. = 80 pt.
80 ÷ 20 = 0.25 lb. of neutralizer in each pint

To neutralize the batch of cream given in Problem 1 (2490 lb. cream, acidity 0.60 per cent) we shall need 34.8 pints of the stock solution as prepared. This should have an equal volume of water added before using in the cream.

2490 × (0.60 — 0.25) = 8.71 lactic acid
8.71 ÷ 0.25 = 34.8 pt. of neutralizer solution

34.8 pt. solution + 34.8 pt. water = 69.6 pt., or about 9 gal. of solution ready for use.

Caution: Stock solutions of soda neutralizers should not be stored in metal containers. Earthenware jars are suitable. Because of the high solubility of sodas, stock solutions are unnecessary.

The following summary from Oklahoma Station Bulletin 226, 1935, by Fouts and Keith,[12] is considered a very practical and reliable guide on cream neutralization.

> Results of these experimental trials indicate that when high-acid cream (0.60 per cent or above) is to be used for buttermaking purposes, it is desirable to double neutralize, using a magnesium lime and sodium carbonate. Neutralizing two-thirds of the excess acid with magnesium lime and one-third with sodium carbonate proved satisfactory. Other proportions of lime and soda also were found to yield satisfactory results. Calcium or magnesium limes alone often caused noticeable neutralizer flavor in the resulting butter. Sodium bicarbonate, when used with either calcium or magnesium limes, frequently imparted a bicarbonate flavor to the resulting butter. It has also been found desirable, particularly if the acid is 0.80 per cent or over, to add the lime mix in several installments to decrease the severity of the reaction.
>
> Results of similar experiments using cream of medium and low acidities were as follows:
>
> Cream with an acid content between 0.40 and 0.60 per cent may be satisfactorily neutralized by a single application of magnesium or calcium lime. The magnesium again showed a slight advantage over the calcium lime.
>
> For cream with an acid content below 0.40 per cent treatment with either of the limes or sodas studied proved satisfactory with some advantage indicated for magnesium limes and sodium carbonate.
>
> As the acid content of cream increases, the need for care in every phase of the process of neutralizing becomes greater. Too much emphasis cannot be placed on the need for accurate acidity tests, selection and use of high grade chemicals, proper strength of mix, and correct method of adding. It should be realized that there are other causes of neutralizer flavor in butter besides simply adding too much neutralizer.
>
> Only high quality neutralizing materials prepared especially for use in sour cream should be used. The neutralizing mix should be prepared exactly in accordance with the directions as set forth by the manufacturer. It should be added to the cream slowly from some sort of sprinkling apparatus so that it becomes thoroughly distributed immediately. Neutralizer mix should never be just poured into the cream.

Neglecting any one of these points may cause a limy flavor or be responsible for some other serious defect in butter.

Keith's Test for Neutralization.[13] A simple test requiring simple methods and little time is that outlined by Keith, as follows:

Procedure—Weigh out 9 grams of cream into an Erlenmeyer flask or beaker.

Add 75 cc. distilled water

Add 9 cc. of 1/20 normal HCl.

Mix thoroughly, allow to stand 1 minute.

If cream has been neutralized to the extent of 0.1 per cent acid reduction, it will curdle and a thin watery part separates out at the bottom.

Theory. Neutralizers in cream act as buffer salts and vary the amount of acid or alkali required to affect the acidity of the cream. The neutralizers prevent re-solution of the casein due to excessive acid added in the test. The type of neutralizer does not affect the results.

RECENT DEVELOPMENTS IN CREAM NEUTRALIZATION

(Largely experimental—not fully tested in creamery practice)

Recent work by research workers may alter our conceptions of proper neutralization of cream. The main consideration in these investigations appears to be the keeping quality of butter. Fat losses in the buttermilk are also affected by the extent of acid reduction in the cream.

While 0.25 per cent acidity in cream has long been considered a safe point in neutralizing sour cream, it also has been observed that cream with lower acidities may be safely reduced to a lower point, perhaps 0.18 to 0.20 per cent. Few creameries attempt to reduce to lower points because of the danger of "neutralizer" flavor in the butter. It is conceivable that further slight reductions might be made on a very carefully controlled basis. The acidity of sweet cream ranges from 0.10 to 0.13 per cent. Attempts to neutralize cream acidity to points close to that of sweet cream cannot be recommended because the average operator does not work with exact figures relative to pounds of cream, carefully determined acidity tests, etc. In addition he is inclined to rush the addition of neutralizer and may be using solutions which are too concentrated. Carbon dioxide gas in cream and differences in the shade of pink color obtained in making acidity tests indicate that results vary somewhat in different plants, and with different lots of cream in the same plant. In view of these considerations and others which are involved, it seems advisable to have a reasonable margin of safety above the normal acidity of sweet cream. Until more exact methods of control are available and until processing methods are standardized and carefully performed, we must not take chances on reducing cream acidity too low.

E. W. Bird [14] of the Iowa Station indicates that there appears to be a need for a change in concepts regarding the churning acidity of cream and the acidity of butter. Churning acidities lower than 0.25 per cent gave butter with a serum at about the neutral point, or slightly on the alkaline side. This butter kept better in storage than butter made from cream with acidities as high as 0.25 per cent. It is pointed out, however, that neutralizing charts are unreliable in reducing cream acidities considerably below 0.25 per cent. In general, neutralizers leave higher acidities than desired in the low-acid range and lower acidities than desired in the higher acid range. It appears that new values will need to be worked out for lower acid ranges.

The following figures are from a report [14] by Dr. Bird:

Titratable acidity of cream	*p*H of cream with various neutralizers				
	mg lime	NaOH	Na_2CO_3	$NaHCO_3$	Na_3PO_4
0.25%	6.1	5.9	6.3	6.3	6.4

*p*H desired in cream	Approximate corresponding cream acidities				
	Mg lime	NaOH	Na_2CO_3	$NaHCO_3$	Na_3PO_4
7.0	0.11%	0.11%	0.16%	0.16%	0.16%

(*p*H 7 = neutral; less than 7.0 is acid; more than 7.0 is alkaline.)

It is indicated that butter should never be below pH 6.6 and that 6.8 to 7.4 values are desirable. This would indicate 0.11 to 0.16 per cent acidity in the cream at churning.

Bird, Fabricius, and Breazeale[15] submit graphical data which confirm results previously reported by Bird. A study of these graphs confirms the statement that acidities attained in neutralizing cream are higher than calculated in the low-acid range. If calculated results are to be harmonized with actual results in acidity reduction, additional amounts of neutralizers seem to be required. Also, the additional amount varies with different neutralizers.

Explanations of the additional amounts of neutralizer required have not been advanced. Two possibilities may be suggested. When free acids are neutralized, (*a*) both limes and sodas may form compounds with the proteins of cream, (*b*) sodas, in particular, may form buffer salts which interfere with correct acidity determinations. Consideration (*b*) suggests the possibility that pH measurements on cream instead of acidity tests may be the answer if lower cream acidities become general practice in cream neutralization.

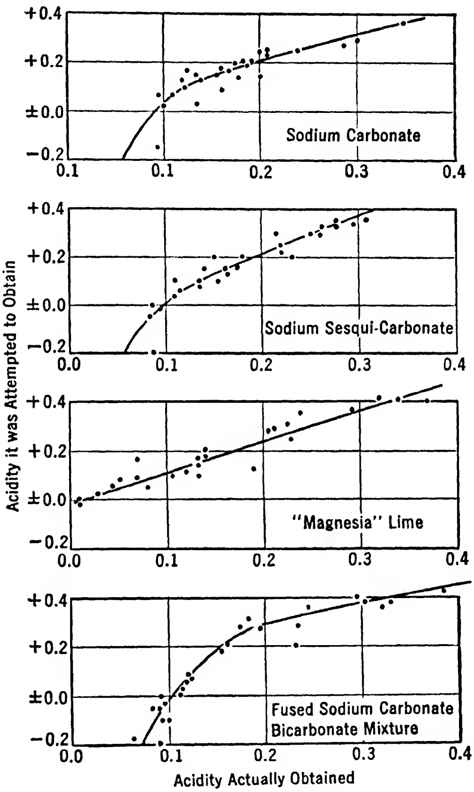

FIG. 34. How neutralizers react when cream is neutralized below the usual acid-reduction point. Courtesy, E. W. Bird, Iowa State College.

Dr. Nelson[16] of Montana states that butter serum should show pH values of 6.6 to 7.0 In terms of acidity, this is slightly on the acid side (pH 7.0 is neutral). Fifteen minutes is suggested to allow for limes to react at 80° to 85° F. When sodas are used, 10 minutes is recommended to allow for reaction before the cream is heated above 85° F. In double neutralization, the proper period is allowed for each neutralizer.

In connection with the interest in acid reduction to lower points for churning cream we present these graphs (Fig. 34). It is of interest to note that only magnesia lime represents a straight-line function to acidities as low as zero or neutrality. This is not readily explainable on the basis of the alkali binding power of casein, for calcium is also present in magnesium limes.

The soda neutralizers show less acid reduction than calculated in the lower acidity ranges. This is probably explainable on the basis of the buffer effects of the salts resulting from the addition of these neutralizers.

Cream acidities as follows are recommended by Nelson:

Single Neutralization

Mg lime	C. A. S. or $NaHCO_3$	Neutraline
0.13 to 0.15%	0 18 to 0 20%	0.24 to 0.25%

Double Neutralization

Mg lime and C. A. S.	Lime and neutraline	Anderson "A" and Anderson "B"
0.20%	0.25%	0.22%

It will be noted that where double neutralization is practiced, and presumably with cream of higher acidities, the figures recommended are quite in line with commercial practices. With single neutralization, and presumably with cream of lower acidities, acidity may be reduced to a lower point than is universally practiced; but Nelson indicates longer reaction periods than are generally used before continuing the pasteurizing process. Also attention should be drawn to the fact that reduction of acidity to different points for different neutralizers is recommended.

Washington State College[17] reports studies on 700 samples of butter stored at 2.5° C and 21° C. Three types of butter were represented:

a. From cream without neutralization or culture.
b. From neutralized cream but no culture.
c. From neutralized cream with the use of culture.

Butter *p*H values less than 6.2 showed no harmful flavor effects on classes "a" and "b" butter when fresh. Such values did materially reduce the scores after a month's storage at 2.5° C. Neutralized butter with starter used showed lower scores when fresh, with *p*H values of less than 6.2. The *p*H values greater than 6.8 produced lower flavor scores on all three classes of butter, both when fresh and after one month's storage. The experimenters believe that *p*H values over 6.8 in butter are a result of overneutralized cream, and that such butter scores less and will not store well.

Parfitt[18] offers data showing the relationship of neutralizer flavor criticisms to the *p*H of butter. These figures represent about 3000 samples of Indiana butter. The plants submitting the butter neutralized cream to 0.20 to 0.25 per cent acidity. The data are as follows:

Relation of *p*H of Butter to Occurrence of Neutralizer Flavor

*p*H of butter	Per cent of Samples Criticized As	
	Slightly neutralized	Neutralized
below 5.0	2.9	4.5
5.1–5.5	8.8	2.2
5.6–6.0	26.5	25.0
6.1–6.5	32 3	31.9
6.6–7.0	14.7	22.7
7.1–7.5	2.9	13.6
above 7.5	2.9	0.0

It will be noted that the greatest number of "neutralized" and "slightly neutralized" flavor criticisms were given the butter which represents the bulk of commercial butter. The *p*H range of commercial butter is usually between 6.0 to 7.0.

The whole subject of acid reduction in cream and its effects on the flavor and keeping quality of butter is undergoing much study. Until these studies are completed and the facts presented in usable form to the creamery operator, it is advisable to follow accepted procedures and standards.

QUESTIONS

1. Describe an acid; a base.
2. What is a buffer in chemical reactions?
3. How old is the practice of cream neutralization?
4. Describe its early history and acceptance.
5. What is double neutralization, and what is its object?
6. Why does the first pink color fade when making acidity tests?
7. Will high-acid neutralized cream make butter of the same quality as fresh cream at the same churning acidity? Why?
8. Why should a sample of cream be weighed for the acidity test?
9. Why should neutralizers be added slowly to cream?
10. When should we make an acid test to determine the accuracy of neutralization? Why?
11. What would be the result if cream with 0.50 per cent acid or more were pasteurized without previous neutralization:
    a. With respect to filtering?
    b. With respect to fat losses in the buttermilk?
12. Which are cheaper to use, limes or sodas? Why?
13. Why do we speak of a lime mix and a soda solution?
14. Why are some lime neutralizers stronger than others?
15. List the advantages and disadvantages of lime and of soda neutralizers.
16. Name three primary objects of neutralization.

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CHAPTER 8

PASTEURIZATION

Definition. As applied to buttermaking and market milk pasteurization may be defined as a process of heating milk or cream to a temperature sufficiently high to destroy the great majority of the bacteria and other ferments (enzymes, yeast, and mold) contained therein and cooling it quickly to a low temperature. The name is derived from Louis Pasteur, an eminent French scientist, who, in the years 1860-1864, made the discovery that if wines were heated to a certain temperature (70° C. or 158° F.), and cooled again, fermentation would stop.

In 1884 Soxhlet applied heat to milk for destroying bacteria.

Objects of Pasteurization of Cream:

1. To insure better keeping quality in butter by destroying bacteria, yeasts, mold, and enzymes.
2. To kill all pathogenic organisms.
   a. Safeguard public health.
   b. Buttermilk is rendered safe for livestock.
3. To make a more uniform product.

Butter from unpasteurized cream will not store well unless it is made from fine sweet cream and is processed under unusually sanitary conditions. Even then, very low storage temperatures are essential. Because a large part of commercial butter must be stored at seasons of high production, pasteurization of cream is decidedly advantageous and is economically sound practice.

Before pasteurization became standard procedure in handling cream, butter held in storage frequently became moldy. Mold grows largely on the surface of butter but may also develop throughout the entire mass. Either condition is very detrimental, and internal mold development entirely ruins the sale of butter for food. Efficient pasteurization is essential in prevention of mold but does not preclude its development. Every precaution against re-contamination must be taken. For details, see Chapter 18, "Sanitation."

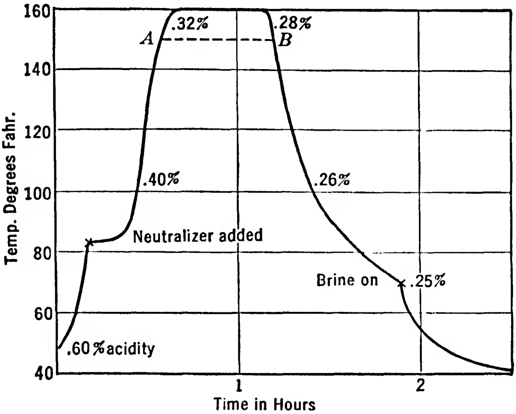

FIG. 35. Neutralization—Pasteurization. Typical graph showing time-temperature relationship. Figures following line of graph represent approximate rate of acid reduction in cream when soda is used as a neutralizer. CO_2 gas is cause of delay in reaching 0.25 per cent point desired. *A*--*B* is temperature for second-grade cream.

Pasteurization temperatures used in the butter industry exceed requirements to kill pathogenic bacteria. Not only must butter be clean and wholesome, but it must also be safe from the standpoint of disease. Pasteurization of cream for butter therefore fulfills a definite ethical obligation.

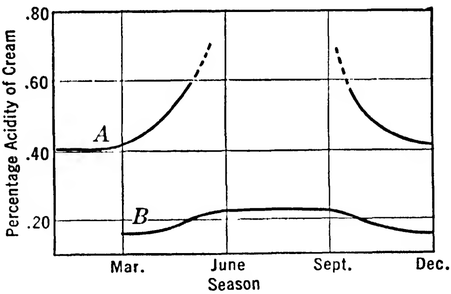

FIG. 36. Theoretical representation of season of year, acidity of cream, and extent of neutralization. *A*—acidity of raw unneutralized cream. *B*—acidity of cream after neutralizing and pasteurizing. (Low-acid cream can safely be reduced to lower acidities.)

Time—temperature relationships in pasteurizing cream for buttermaking are relative. Authorities differ in recommendations. Good cream does not suffer ill effects from 160° F. for a 30-minute period. Poor cream frequently does suffer from temperatures above 150 to 155° F. if held 30 minutes. Butter from cream, so treated, may have a coarse burnt neutralizer flavor. (See Fig. 35.)

Butter made from unpasteurized cream is variable in flavor. Greater uniformity results when the cream is pasteurized. Uniformity increases marketability.

The feeding of buttermilk to livestock is highly desirable. Experiments have proved its merits as stock food. It is most necessary that livestock be protected from contagions that might result from the use of unpasteurized buttermilk. Most of the forty-eight states were in 1938 accredited areas with respect to tuberculosis. Bang's disease, or contagious abortion is being eradicated rapidly. There is every need that all buttermilk should be from pasteurized cream, which makes both butter and buttermilk safe. We cannot afford to endanger healthy livestock.

Storch Test for Pasteurization. Storch, at the Royal Agricultural Experiment Station, Copenhagen, Denmark, was the first to apply general pasteurization to cream for buttermaking. Denmark has a law making pasteurization compulsory. This law was enacted chiefly to prevent the spread of tuberculosis among the herds. The law requires that milk or cream must be heated to 80° C. or 176° F. Samples of skim milk from the creameries are required to be sent to the Experiment Station, where they are tested by the Storch test to ascertain if creameries are complying with the requirements of the law.

Storch found that, of all the reagents that might be used for determining whether milk or cream had been heated to 80° C. or 176° F., the best was paraphenylene diamine. This compound ordinarily gives a brown color when acted upon by "active" oxygen, but in the presence of casein in milk the color is a beautiful indigo blue.

To carry out the test, about 5 cubic centimeters of milk or cream are put into a test tube, and one or two drops of a 0.2 per cent solution of hydrogen peroxide are added from a dropping bottle, also two drops of a 2 per cent solution of paraphenylene diamine. Brown-colored bottles should be used to prevent the light from weakening the reagents. The test tube is then shaken well, and if the milk has not been heated above 78° C. or 172° F., or if not heated at all, an intense blue coloration is produced. If at once or after a half minute the milk becomes bluish-gray, this color indicates that it has been heated to a temperature of 78° to 80° C., or 172° to 176° F. When the color of the milk is unchanged after addition of the reagents, it may be concluded that the heating has exceeded 80° C. The blue color that develops on standing has no significance.

Storch's test has shown itself to be the most reliable of all the methods proposed for distinguishing heated from unheated milk. All the so-called improvements on the Storch test which have been advocated by other chemists have proved to be of little benefit, often indeed the opposite.

If during the pasteurization of the milk the temperature falls below 80° C. for a time, the whole of the milk after being mixed reacts to Storch's test. The sensibility of the test is so great that the admixture of 10 per cent of milk which has been heated to only 78° C. suffices to make the whole volume of milk react to the test. For Zakaraisen's modification of Storch test for cream, see Chapter 19, "Testing."

METHODS OF PASTEURIZATION

Four general methods of pasteurizing are used, viz.:

1. Vat or batch.
2. Flash or continuous.
3. Regenerative or heat exchange.
4. Combination flash and holding.

A fifth method, consisting of the injection of live steam into the cream, is being used to a limited extent in the Middle West butter-producing section. This method makes use of the Cooney-Keating pasteurizer, which is made at Yankton, South Dakota. It is in principle the old Grinrod process. Dilution of the cream with the steam condensate is one objection offered to its use.

Vat or Holding Method. The vat method which is used most extensively in the local creameries, is the most practical and economical because of the limited volume of cream handled. The extra investment required in both the flash and regenerative systems is not justifiable.

Advantages of the vat method are:

a. Less investment.
b. Less equipment to clean and keep repaired.
c. More accurate temperature control.

Disadvantages of the vat method are:

a. Greater wear and tear upon vats.
b. Saving cream until enough accumulates for a run.
c. Greater heating and cooling costs.
d. Greater mineral salt accumulation in the coils of the vat owing to alternate heating and cooling, thus reducing the conductivity of the coils.

Standard practice in vat pasteurization until recently consisted of heating the cream to 145° F. and holding at this temperature for 30 minutes. Although these figures have been considered satisfactory for many years, higher temperatures are now being used. Temperatures of 150° to 165° F., with holding periods of from 30 minutes to 15 minutes, are more commonly used. Guthrie, Scheib, and Stark [1] of Cornell University show that 165° F. for a 30-minute holding period produced butter of the best keeping quality. After the holding period, cold water is passed through the coil until the temperature is reduced to a point within 10 to 15° F. of the temperature of the water. From this point, the cooling proceeds so slowly as to make it impractical to attempt further cooling with water.

The facts concerned at this point are:

1. Excessive agitation of the cream would result.
2. Water and power are used uneconomically.
3. This temperature is one quite suitable to bacterial growth and delay in cooling is false economy.
4. Time is wasted. If churning is to be done the same day, operations are seriously delayed.
5. Partial churning and mealy butter may result.

All water in the coils should first be eliminated before starting the circulation of brine, in order to prevent brine dilution. When cooling is completed the same care should be exercised in seeing that all brine is removed from the coils and returned to the brine tank so that brine is not carelessly wasted. Removal of both water and brine are effected by opening the vent on the vat, allowing air to enter and replace the brine. If this is not done, a partial vacuum is created and the pump cannot draw the liquid from the coils.

Principle of Autocirculation in the Horizontal Coil Vat. Where cream is heated and cooled in the same vat, the coil is used as the circulating device. Reference is made here to the circulation of the heating or cooling medium. These vats are provided with a small

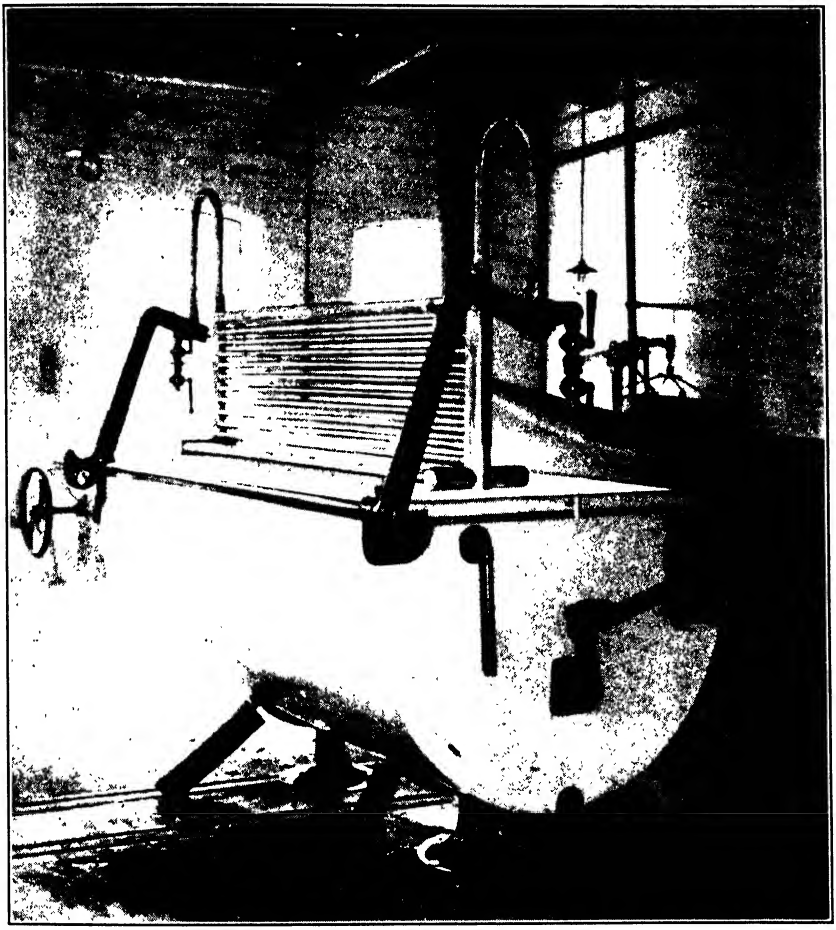

FIG. 37. One type of Danish cream vat. Heating and cooling coils may be raised and lowered. Agitation accomplished by rocking the coil. Courtesy Paasch, Larsen and Petersen; Horsens, Denmark.

tank where the water is heated by live steam. The newer vats do not have this tank. A small drum provided with an overflow is installed in the heating line, and only the water in this drum and in the coil and connections is heated and circulates. This is more economical from the standpoint of heat units required and results in more prompt heating, because the delay in heating 25 to 50 gallons of water is eliminated.

The action of the coil in producing the circulation is that of a pump in the sense that the circulating medium can actually be elevated some distance above the position of the coil. Installations have been made where the water used for cooling is conducted to a tank on the floor above, and there it serves as a reserve supply for washing cans, vats, etc.

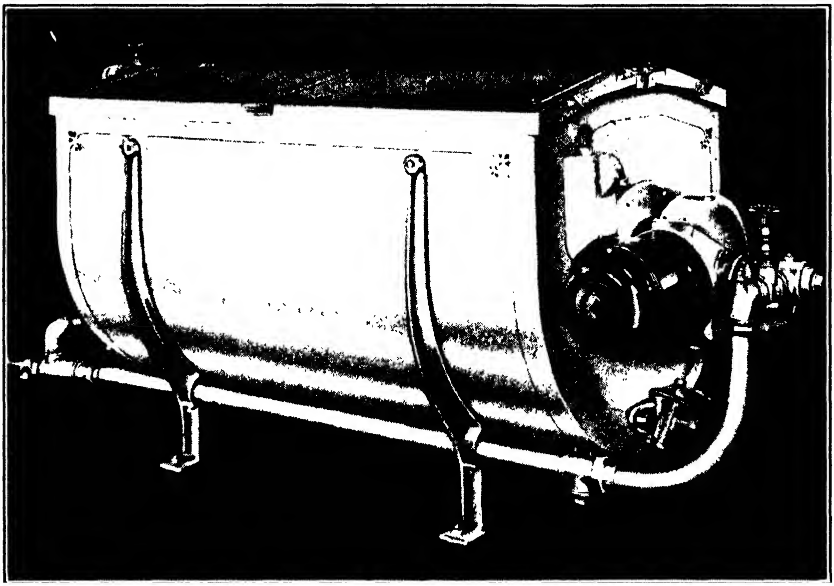

FIG. 38. Standard motor-driven cream vat. Courtesy Cherry-Burrell Corporation.

In order to use the centrifugal force of the revolving coil to circulate the water there must be sufficient air admitted to the coil to fill the top half approximately. As the coil revolves, the water flows downward in the coil, keeping the lower half filled, and, as it converges toward the outlet, its momentum carries it out with sufficient force to elevate it several feet above the level of the coil. Naturally, as the water is forced from the outlet, water from the circulating tank must be drawn into the coil and the circulation proceeds. An amateur often encounters difficulty in admitting the right amount of air and, consequently, may fail to start the water circulating. This circulation is used during the 30-minute holding period and may be used if the final cooling is done with ice water instead of brine.

A new vat recently developed does not depend upon coil movement for circulation of the water for heating or cooling. A centrif-

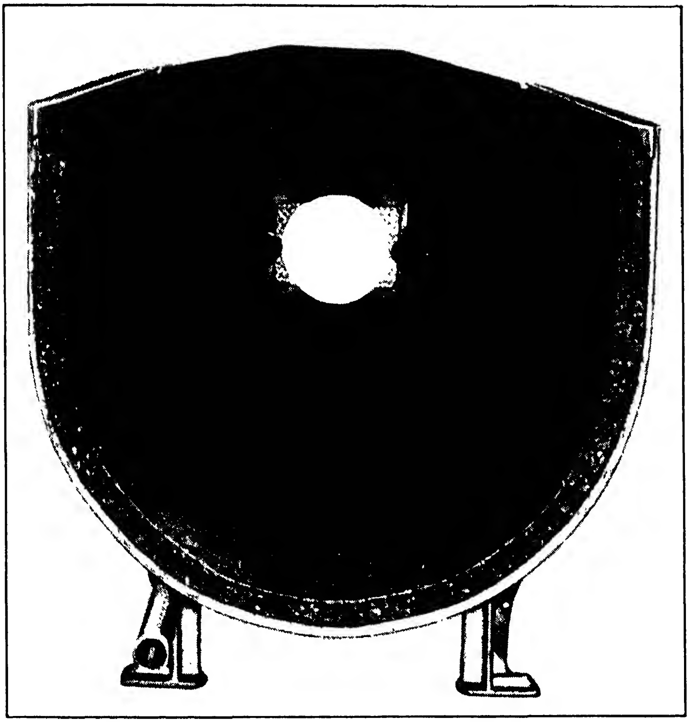

FIG. 39. Cream-vat insulation. View showing heavy 2-inch solid corkboard insulation. This assures the close holding of temperatures so necessary in processing many heavy-bodied products. Necessary for efficient holding and storing of all dairy products. Courtesy Cherry-Burrell Corporation.

ugal pump attached in the feed line forces the water through more rapidly. The possibility of live steam entering the coil when the water gets very hot is eliminated. A lower temperature of the heating medium is possible, and the development of cooked flavors is probably retarded. The piping used for the coil in this vat is elliptical instead of round. This allows for more coil surface (coil length) for heating or cooling and also insures more rapid agitation of cream.

In 1925 Dr. Marker, of the Canadian Northwest, recommended heating cream to 170 or 175° F. and holding for 15 to 20 minutes. Butter made from cream so treated has shown very good keeping qualities. This is explained upon the basis of more thorough destruction of bacteria, yeasts, and molds, as well as the enzymes of milk. The enzymes of milk which have been found in butter are lipase, catalase, and peroxidase [2]. It is not certain that appreciable changes occur in storage butter from the effects of these enzymes, although Rogers [3] showed lipase was the cause of increased rancidity in canned butter. Later Rogers, Berg, and Davis [4] demonstrated that milk was able to hydrolize ethyl butyrate and that this property of milk is much reduced when milk is heated to 150° F. and is destroyed when heated to 176° F. A number of enzymes are not completely destroyed even at 175° F.

It is questionable, however, if heating to 170° to 175° F. can be recommended on account of the danger of cooked flavor in the cream and in the butter. The holding period would need to be relatively short and the temperature should be raised slowly from 150°. The cream should cover the coil completely.

Precautions in Vat Pasteurization. Cream should not be heated too rapidly. With the injector-type heater, there is danger of overheating portions of the viscous cream. On the contrary, there should not be unnecessary delay through the range of temperatures where bacteria thrive. As the holding temperature is reached, it is advisable to retard the steam injector somewhat in an effort to reduce the danger of imparting a cooked flavor to the cream. This is particularly true if temperatures of 160° F. or over are used.

Modern cream vats have flush-type valves on the cream outlet. These valves are attached very close to the vat and eliminate the so-called "dead-end" which exists in the outlet of the older vat. Where dead-ends do exist, the operator must draw a pail of cream from the vat after the maximum temperature has been reached and pour this back into the vat. Failure to do this frequently results in faulty pasteurization and should be avoided. Such outlets to vats should be carefully cleaned and brushed each time the vat is washed. They should be removed from the vat periodically and inspected for cleanliness.

Occasionally, we find creameries where ceilings are defective. If the ceiling is cold, moisture may collect on it and drop back into the cream. Such a condition should be remedied at once, either by repair of the ceiling or protection to the vat by a suitable canopy, or both.

Another consideration in vat care is the occasional neglect of the tie-boards at the top, to which the lids are hinged. Cream splashes onto this panel and, if it is not washed each time the vat is cleaned, trouble may follow from condensate drippings.

Horizontal-coil cream vats have bearings in each end of the vat. Some operators are careless about keeping packing glands sufficiently tight and about renewing packing. Modern vats provide access to these glands, and the efficient operator must be methodical in caring for them. They can be kept in sanitary condition but the negligent operator may have difficulty in keeping them so. Proper care of these bearings will prevent the possibility of cream passing into the bearings and becoming foul.

Vertical coil vats do not have coil bearings in the walls of the vat. They are suspended from the vat cover. This may be claimed as a point of superiority. They also occupy less floor space. The coil-driving mechanism is located on the cover of the vat. This might be claimed as a disadvantage from the standpoint of grease and oil over the vat. Enclosed drives however, largely eliminate the danger of grease getting into the cream. When vertical coil vats are partly full, a portion of the coil is ineffective in heating and cooling, as it is not submerged. Agitation of the cream is also less complete with a partially filled vat. If neutralization of cream is attempted with partially filled vats, special care is required to prevent dripping of alkali on the upper coil and to see that the neutralizer is added slowly and in proportion to the rate of mixing with the cream.

Flash Pasteurization. Flash or continuous pasteurization is best suited to large-scale operation. It is obvious that cream must be received in great quantity in order to keep such equipment in continuous operation. This method of heating and cooling is the most efficient from the standpoint of costs of operation. It is doubtful if better butter can be made from good cream pasteurized by this method than by other methods. When cream contains various off flavors and is considerably fermented it may be improved by the high heat of flash pasteurization, or it may be harmed. Much depends upon the type of cream, its age, previous handling, temperature used, time of heating and cooling, etc. Although it is no

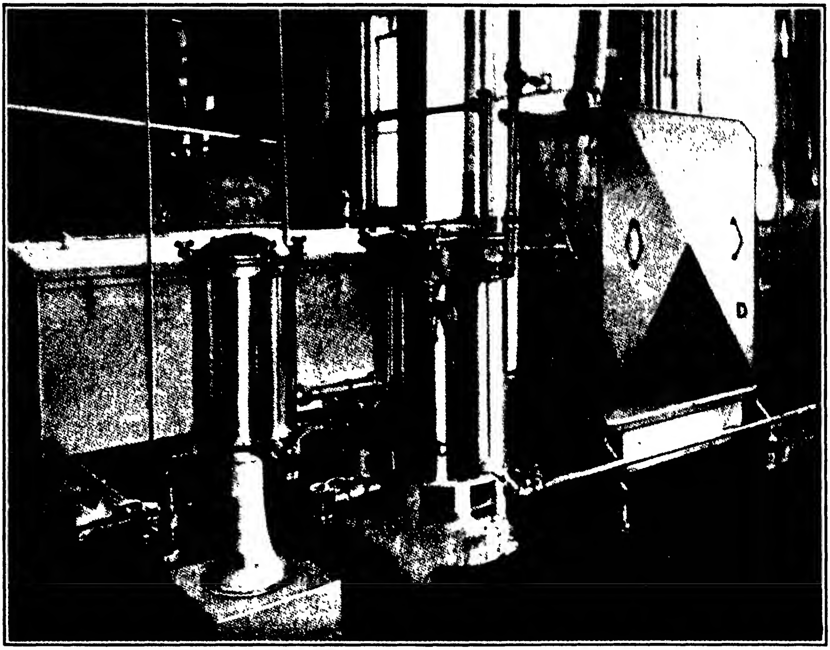

FIG. 40. Installation for flash or continuous pasteurization of cream. *A*—cream vat. *B*—filter. *C*—flash pasteurizer. *D*—cabinet cooler. Courtesy Cherry-Burrell Corporation.

doubt true that the effects of light and air on cream passing over an open air cooler are not altogether desirable, we believe that the beneficial effects outweigh any detrimental factors. It is known that exposure of hot cream to light and air has a tendency to stimulate oxidation of the fat and to induce tallowy and metallic flavors. This danger is minimized if the coolers are well tinned and if the cream is cooled from 180° F. to 140 or 145° F. before passing over the coils. This can be done by precooling in an internal tube cooler or by use of the regenerative system of pasteurization.

The most common installation of equipment in flash pasteurization consists of a series of two flash pasteurizers. The cream passes from the forewarmers, where the neutralizing is accomplished, to the first flash machine. From the forewarmer temperature of 80° to 90° F. the temperature is raised to about 140° F. From the first machine it passes to the second, where the temperature is raised to 180° to 190° F. From this machine it passes at once

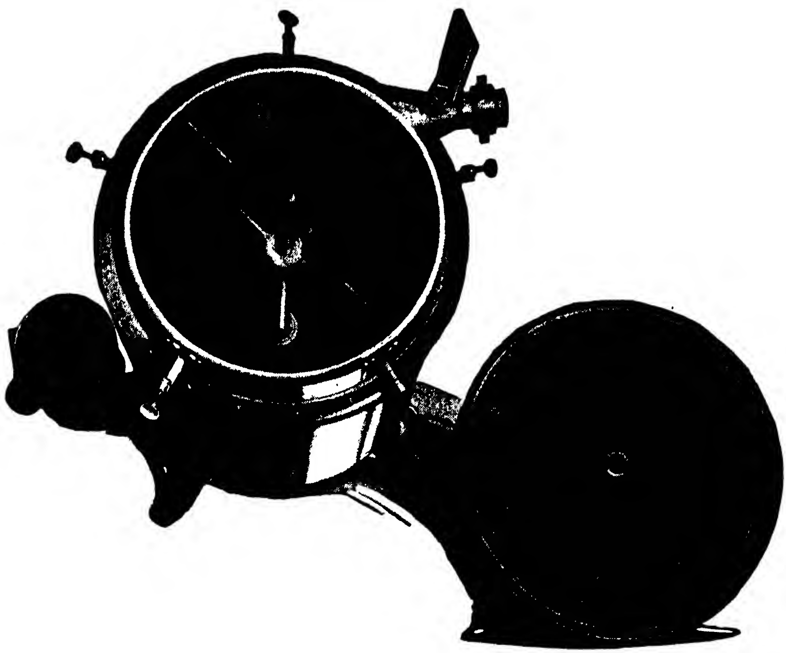

Fig. 41. Top view of the Reid centrifugal heater, with lid removed showing impeller. May be used for flash pasteurization of cream. Courtesy Chester Dairy Supply Company.

over the open air cooler and from there to the holding vats, where the temperature is adjusted according to the buttermaker's judgment. The open air coils may be connected to use water only if the supply is cold enough, or may have both water and brine connections. Usually only brine is circulated in the holding vats.

The practical plant arrangement for supplying heat to the flash machines consists of directing the live steam to the final pasteurizer where the cream is heated to 180° to 190° F. The outlet or exhaust from this machine passes to the first pasteurizer and the steam is thus used twice before exhausting. A few installations in large central creameries are similar to the foregoing description except that the cream is heated to 180° F. in the final flash machine and passes from there over open air coils which heat the cream to 190° F. From these coils it passes at once over open air cooling coils and then to the vats. This procedure may well be questioned from the standpoint of exposure to air and light.

The advantages and disadvantages of the flash system may be summarized thus:

Advantages:

a. Economical heating and cooling.
b. Cream processed as soon as received.
c. Saves wear and tear on cream vats.
d. Permits aeration of poor cream.
e. Speeds up operation.

Disadvantages:

a. Not suitable for creameries of limited volume.
b. Additional investment in equipment.
c. Additional apparatus to keep clean.
d. Possibility of cooked flavors.
e. Needs constant watching to maintain proper temperatures.

Flash Pasteurizers of the Cylindrical Type. These machines are the so-called enclosed types. They are jacketed, and the heating medium, usually live steam, enters the jacket. A condensate overflow is provided. Stainless steel is now quite generally used for the inner wall which holds the cream. The speed of the rotor serves to impel the cream against the heated wall and also elevates it several feet above the pasteurizer. Pumps are not needed to force the cream to the cooling coils. Cream is usually heated to a minimum of 180° F. in order to insure germ-killing efficiency. Temperatures vary somewhat in different plants, according to the kind of cream received, the extent of neutralization, rate of flow of cream, etc. Recently Parker and Brengman[5] indicate that so-called flash pasteurization may be a misnomer. Usually 30 seconds are required to heat cream from 100° F. to 180° or 190° F. Some installations, owing to the distance the cream must travel to reach the

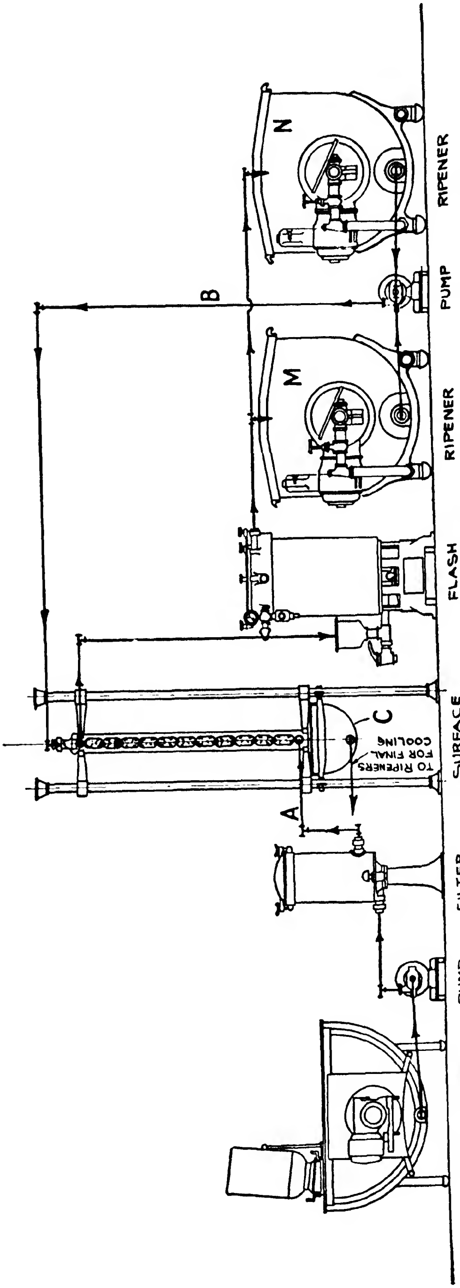

Fig. 42. Plan for arrangement of equipment for regenerative pasteurization. (Prepared for this book by the Cherry-Burrell Corporation.)

cooler, hold the cream at high temperature for an additional 20 to 30 seconds, although 5 to 10 seconds is more common. In reality, then, we incorrectly refer to this method of heating cream as flash or instantaneous. It should be called high-heat, short-time pasteurization.

Efficient operation of flash pasteurizers requires care in all details. All the cream must be heated to the required temperature. Cream must not be allowed to start through the machine until the heating medium is in full flow. Remnants of cream drained from pasteurizers or rinsed from forewarmers must have been properly heated. During the time of operation, the attendant must be constantly present to see that cream temperatures do not drop low enough to decrease pasteurizing efficiency. A balance between the amount of applied heat and the cream flow must be maintained. Thermostatic controls on flash pasteurizers are the best insurance against failure to maintain proper balance.

Regenerative or Heat Exchange Pasteurization. This method, as the term implies, consists of a transfer of heat from the cream to be cooled to the cream to be pasteurized. This system, which is adapted to large factories, is not used much in this country but is used to some extent in foreign countries. It is most economical from the standpoint of heat, water, and power consumed. The general plan of an installation is shown in the diagram, Fig. 42.

It can be seen, then, that cream entering the inside of the coils at 50° F. through pipe *A* is raised by the hot cream to 100° F. Upon leaving the coils the cream passes through the flash pasteurizer where it is heated to 150° F. and transferred to ripeners *M* and *N*. After a 30-minute holding period it is pumped over the coils through pipe *B* and, collecting in trough *C*, passes out to the cooling and holding vat. By passing over the coils it is dropped 50 degrees in temperature and enters *C* at 100° F. In the final holding vat the cream is cooled to the desired temperature and held for churning. Obviously the cream could be passed over a second cooling coil before transfer to the vats, so that little or no cooling need be done in the holding vats.

The above temperatures are possible only when the rate of flow of the cold cream through the coils and the rate of flow of the hot cream over the coils are regulated to correspond to the size and ability of the coil to cool. Even then it is practically impossible to get 100 per cent efficiency of heat transfer, as the figures given indicate. This is especially so with cream, for the butterfat is a poor conductor of heat. Such installations are coming more and more into favor in the milk industry where the heat transfer is more easily effected and where continuous operation is assured.

This system can readily be adapted to flash pasteurization where the flash machine would boost the cream from 100° to 180° or 190° F. and feed it over the coils as through pipe *B*. The holding vats *M* and *N* would not be needed.

The advantages and disadvantages of the regenerative system are as follows:

Advantages:

- *a.* Economical (heat, power, water).
- *b.* Permits aeration of poor cream; except in plate-type exchangers.

Disadvantages:

- *a.* Greater equipment cost.
- *b.* More equipment to keep clean.
- *c.* Not adapted to small creameries.
- *d.* Continuous operation must be assured.

Combination Flash and Holding. It is possible and often practical to combine these two methods of pasteurization. For example, the cream may be received in sufficient volume so it can be flashed to the desired temperature and transferred to a vat where it is held for 30 minutes. It may then be cooled in the vat, as in the common holding method, or it may be pumped over open air coils where it is cooled and transferred to a second vat for holding until churned.

Temperature-Time Relationship in Pasteurization. Various temperatures are used in pasteurization other than those which are accepted in standard practice. When cream is pasteurized in the vat at 145° F., the holding period is given as 30 minutes. It requires but little imagination to believe that, if higher temperatures are used, the time of holding may be proportionately decreased. Following out this reasoning, we could easily conclude that, if temperatures were high enough, the holding period might be decreased to none at all. This is not quite true theoretically and is not possible practically. Necessarily some small amount of time elapses between reaching the maximum temperature and appreciable reduction in cooling.

The following figures from Park [6] give approximate relationships of time and temperature requirements to kill *M. tuberculosis.*

THERMAL DEATH POINT OF *M. Tuberculosis* IN MILK [6]

Temperature	Time in Minutes	Temperature	Time in Minutes
68.3° C. (155 F.)	1	60.0° C. (140 F.)	15
62.8° C. (145 F.)	6	58.9° C. (138 F.)	20
61.1° C. (142 F.)	10	57.8° C. (136 F.)	30

The trend indicated by these figures is comparable to similar relationships for most other organisms. It must be remembered, however, that many bacteria, bacterial spores, and molds are far more resistant and require not only higher temperatures but also longer periods of time in order to kill them. This is obvious if we understand that it is rarely possible to kill all organisms even at 212° F. for considerable periods of time. The figures above reveal to us that common methods of pasteurization of cream, if carried out carefully, render the cream, butter, and buttermilk safe from pathogenic organisms. We deduce this from the fact that *M. tuberculosis* is the most resistant of common pathogenic organisms. The following graph is further evidence of this fact and illustrates other effects of heat on milk.

Note that 150° F., or more, is required to kill the tuberculosis organism when applied but a minute or two. If 30 minutes of time is allowed, the temperature need be only about 138° to 139° F. Note also that the cream line will be the same on milk heated to 158° F. momentarily as on milk heated to 143° F. for 30 minutes. Note also that the taste of milk is not seriously affected by heating to about 154° F. for 30 minutes. This would apply in a general way to cream as well.

Higher Temperatures Used for Cream. It will be observed that vat pasteurization of cream at 145° F. for 30 minutes allows ample margin for destroying pathogenic organisms. In commercial buttermaking, where many organisms of many kinds are encountered it is advisable to heat higher than 145° F. in order to improve the keeping quality of butter. It is indicated from several sources that enzyme activity may in part be responsible for flavor defects in storage butter. Lipase, for example, is greatly weakened at 152° F.

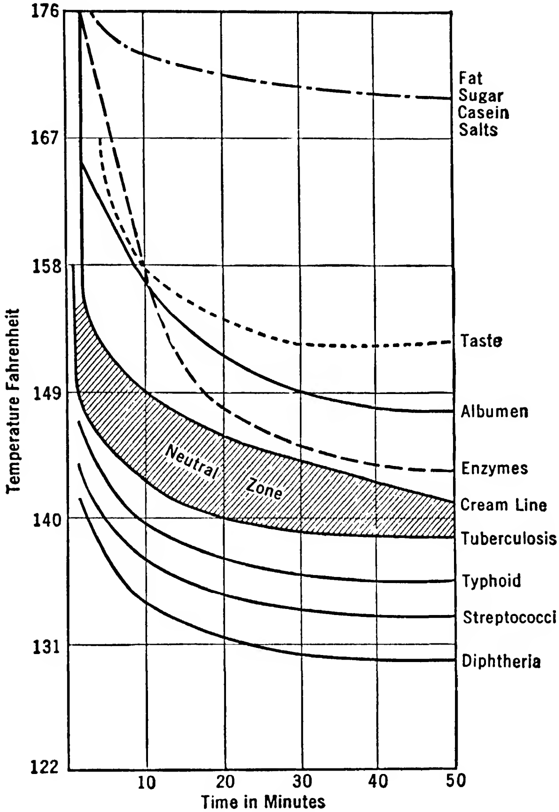

FIG. 43. Time-temperature relationships which effect changes in the microflora, enzymes, cream line, and constituents of milk. From U. S. Public Health Bull. 147, 1925.

and is destroyed at 176° F. *Recent work indicates improved keeping quality of butter when cream is pasteurized at 165° F. and held for 30 minutes. This is in line with Dr. Marker's (Alberta, Canada) recommendations about 1925.*

The figures given on the thermal death point of *M. tuberculosis* are significant from a health viewpoint. Temperatures of 150° to

165° F., with 30-minute holding periods, are now being used in pasteurization of cream to insure improved keeping quality in butter. Molds, resistant bacteria, and enzymes must be killed or inactivated. Modern methods of pasteurization are based on requirements for keeping quality of the butter rather than on requirements to kill pathogenic organisms.

The time-temperature relationships in pasteurization are not definite. Usually 95 to 99.5 per cent of microorganisms are destroyed by efficient pasteurization. However, the efficiency is dependent on:

a. The number and kind of organisms present in the cream.
b. The activity, vitality, and condition of the organisms.
c. Time and temperature used.

a. The greater the bacterial count, the greater the percentage of organisms killed. If cream is quite fermented the percentage reduction is greater, and vice versa.

b. If bacteria are rapidly multiplying, they are more easily killed. If a large percentage is of the spore-bearing type and many are in the spore stage, they are more resistant to destruction by heat and the percentage reduction is decreased.

c. The time-temperature relationships have been previously discussed. It is advisable in all cases to exceed requirements slightly rather than to run the risk of the consequences of failing to maintain standard recommendations.

Hunziker[7] in discussing oily-metallic flavor in butter suggests that 145° to 150° F. for a 30-minute holding period for cream pasteurization is advisable. He suggests that flash pasteurization temperatures of 165° F. are better than higher temperatures and follows by indicating that the holding method used as described above is preferable. Parker and Brengman[5] have flash pasteurized cream experimentally using various temperatures and have determined the numbers and kinds of bacteria which survive. They throw out the challenge of a need for investigation of the whole subject of cream pasteurization. For example, there must be definite temperature and time specifications for flash pasteurization. At present only temperature is specified. Installations differ in most plants and the time of exposure to a given temperature depends on several factors such as, size and length of pipe lines from heater to cooler, the rate of flow of the heated cream, etc. They also raise the question of chemical or biochemical changes in cream as the result of high temperature pasteurization.

Good Milk and Cream Important. The foregoing discussion gives some conception of the accomplishments of neutralization and pasteurization. These practices are general. Conditions compelled their adoption. Pasteurization is made compulsory by law in Iowa and Montana. The butter from these two regions varies in quality. Iowa, with a large percentage of fine butter, requires all cream for butter to be pasteurized. Even though sweet cream of fine quality is used for butter, the keeping quality of the butter is enhanced by pasteurization.

No doubt exceptions may be cited, but compulsory pasteurization is, in general, sound practice. In 1907 one of the authors conducted an experiment which included the making of butter from factory-skimmed cream, one-half of which was pasteurized and the other half was not. The butter made from several such batches of cream was stored in New York and London and was scored about six and one-half months later. Mr. Kiefer of Gude Brothers Kiefer Company scored both lots of butter and the scores were as high as when fresh. He remarked that it was one of the finest lots of butter he had ever seen. Reports from London were very similar, indicating that the raw-cream butter had kept as well as the pasteurized-cream butter.

This is given to show that especially fine cream, even churned raw, may produce butter of exceptionally good keeping quality. It should be emphasized that pasteurization should not be used as an excuse for producing and delivering poor cream.

One outstanding advantage, beside that of killing bacteria, is that *pasteurization results in a more uniform quality of butter.* Another important consideration is the fact that butter from states where pasteurization is compulsory should sell better, particularly during the storage season. The storage season is usually the time of greatest production in May, June, and July. If the butter comes from a state where pasteurization is required by law, the creameries should receive more money at the time of greatest production. This is a consideration of much importance.

Enzyme Inactivation Desirable. The following figures give some conception of the temperatures required for inactivation or destruction of enzymes found in milk and cream.

ACTIVITY OF MILK ENZYMES AS AFFECTED BY *p*H AND HEAT

Milk enzymes	*p*H range of activity	Thermal inactivation point, degrees Fahrenheit
lipase	5.5 to 8.5	176
oleinase	5.5 to 8.5	176
phosphatase	6.0 to 10	145
galactase	6.4 to 7.2	165 to 175
amylase	6.4	140 to 160
peroxidase	6.8 to 7.0	160
protease	....	165 to 175
diastase	5.8 to 6.2	140 to 150
catalase	6.8 to 7.0	150 to 160

Nomenclature, existence of, amounts of, and functions of several other enzymes are much confused in many references. Some enzymes are referred to by several names. Existence of some has been questioned.

In addition to the enzymes normal to milk and cream, enzymes are produced by bacteria and yeast. These enzymes are indeterminable in kind, amounts, and influence upon cream. In order to inactivate them it may be presumed that temperatures comparable to those for normal milk enzymes may be necessary.

Summary of Considerations in Pasteurization. It is unwise to consider that the destruction of either microorganisms or enzymes or both is the criterion. The destruction of any pathogenic organisms is the primary consideration. In heating beyond temperatures necessary for their destruction we must consider also possible chemical changes which may be produced in the cream and the butter. If higher temperatures adversely affect the flavor of butter, then we must find temperatures which are satisfactory in reducing bacterial and enzyme activity, but which are not deleterious to butter flavor. Because of the variable nature and conditions of cream in widely separated areas, it may be recommended that 160° F. for a period of 20 to 30 minutes may serve as a standard. These conditions may be modified with satisfactory results. Any change, however, should not be so drastic as to permit any doubt about the destruction of pathogenic organisms.

QUESTIONS

1. Define pasteurization as applied to cream for buttermaking.
2. List the objects of pasteurization of cream.
3. Describe four or five methods of pasteurizing cream.
4. Reproduce a graph showing time-temperature relationships in pasteurizing a vat of cream.
5. List the advantages and disadvantages of the vat or holding method of pasteurizing cream; of the flash method.
6. Give some reasons why we pay particular attention to the temperature and time required to kill *M. tuberculosis.*
7. Define "pathogenic bacteria" and name some.
8. Why do we heat cream to temperatures higher than is required to kill pathogenic bacteria?
9. What enzymes may be present in butter and have a part in its deterioration? What temperatures are required for their destruction?

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CHAPTER 9

STARTERS AND CREAM RIPENING

Starters Defined. Starter is a very general term and is largely a trade or industrial term. According to Webster's dictionary, the word start means "to cause to move, to rouse." Ferments in the brewing industry could as well be called starters. They contain bacteria or yeasts which cause grain mashes to ferment and develop alcohol. A starter, as used in the dairy industry, consists of sour milk or whey containing the desirable bacteria which, when placed in sweet products, causes a rapid and desirable souring together with certain other special types of fermentation. For example, a starter for Swiss cheese making consists of acid-producing organisms of a special type (*B. bulgaricus*) and, in addition, "eye former," which produces the large round gas holes or eyes in Swiss cheese.

Organisms Found in Starters. The common starter most used in creamery, milk-plant, and cheese-factory processes consists of three distinct species of organisms, viz.:

1. *Streptococcus lactis*—produces lactic acid.
2. *Streptococcus citrovorus*—produces flavor and aroma.
3. *Streptococcus paracitrovorus*—produces flavor and aroma.

The flavor-producing organisms also produce volatile acids from the citric acid in milk.

The first organism, usually referred to briefly as *S. lactis*, produces lactic acid by breaking down the lactose or milk sugar. This lactic acid has very little if any odor. It is only sour. The other two organisms produce the desirable flavor and aroma in starters, using, among other milk ingredients, the citrate or citric acid content of milk. Increased or added amounts of citric acid to starter milk have produced higher-flavored starters which have been scored higher by experienced starter judges.[1]

A good starter must have *S. lactis* and, in addition, either of the other two organisms. It may have all three, but two are sufficient. Most starters, however, have all three organisms.

Purpose of Starter. A starter is used by many buttermakers who like the additional flavor and aroma which it produces. They also may be making butter for a particular market which demands a starter-flavored butter. The controlled and moderate use of starter definitely improves butter made from off-flavored cream. In sweet cream it adds flavor which many people prefer. Its use during the grass season when cream and butter naturally have higher flavor may not be so necessary, but it is believed desirable at this time also from the standpoint of uniformity of flavor in butter. There is, however, a growing market for unripened sweet-cream butter which is to be encouraged. Sweet cream, with proper sanitary procedure in manufacturing, produces butter which has outstanding keeping quality. The United States Navy demands such butter for its services. Its superior keeping quality is the important consideration.

History of the Use of Starters. The use of starters in the dairy industry dates back a great many years. The fact that starters helped in the manufacture of dairy products was recognized years ago by practical men even before scientists recommended the use of pure cultures. In European dairy countries the borrowing of buttermilk from a neighboring factory to add to the cream in order to overcome abnormal conditions was a common practice. In Holland, sour whey borrowed from some other factory was used to overcome gassy fermentation in cheese making. Though the reasons for this were not well understood, the underlying principle involved was that of overcoming the undesirable fermentation by adding desirable ferments, which became dominant.

Introduction of Commercial Starters. Carefully prepared commercial starters for cream ripening were introduced in 1890, when Professor Storch recommended their use in creameries in Denmark. After commercial starters had been used long enough in that country to demonstrate their worth, they were introduced into this country as well as practically all the European countries. They are now employed quite extensively.

Selection of Milk for Starters. Only high-grade milk should be used. This means that milk should come from healthy cows and should be produced under sanitary conditions. It should be cooled promptly after milking and should be delivered to the creamery without delay. The person responsible for propagating the culture must see that the milk is clean and normal in flavor. Questionable milk may be the cause of poor results with starter. It is a quite universally accepted fact that a poor starter is worse than no starter. Extreme care is necessary to carry a starter for weeks and maintain its purity and flavor-producing properties. The same man should do this work continuously. He should have suitable equipment and the necessary time to perform the task carefully and methodically. A daily routine and schedule should be followed. If the starter is unsatisfactory and cannot be "nursed" back in two or three days, a new culture should be secured from the laboratory.

Mother Starter and Bulk Starter Defined. Mother starter or culture consists of a small amount of milk which contains the proper starter organisms in good growing condition. Original cultures are obtained from a commercial laboratory. This culture is carefully placed in the quart jars of milk which have been heated and cooled as described below. The conditions and procedure in propagating mother culture should be as much like standard laboratory practices as possible. Sanitary precautions are to be constantly observed.

Bulk starter consists of large quantities of milk prepared in vats or starter cans. The milk is heated and cooled before inoculation, as in preparing mother cultures. Large-scale operation, as with bulk starters, does not permit of such strict sanitary precautions and temperature control as are required with mother cultures. Vats and covers are not sterile. Temperature control is not so exact, but carelessness is to be definitely avoided. The bulk starter is usually for immediate use, and, since it is not employed for propagation, extreme caution is not so necessary.

Heating Milk for Starters. The milk for both the mother cultures and the bulk starter should be heated to 180° to 190° F. and held at this temperature for at least one-half hour. The time-temperature relations here are midway between ordinary pasteurization and sterilization. Sterilization requires that boiling temperature be used for an hour or more, and for laboratory practices milk must be heated under 10 to 15-pound steam pressure for one-half hour.

This provides a sufficient margin of safety and voids any question of sterility. These pressures produce a temperature of 240° to 250° F. and are analogous to practices in making and sterilizing evaporated milk, which keeps indefinitely without refrigeration because it is sealed and is sterile. By heating starter milk as described above we do not kill all the bacteria. We do provide a milk which, when properly cooled, gives the starter organisms introduced a rather clear field in which to develop and so to predominate in numbers that any unkilled organisms are unable to do harm. After heating, the milk should be promptly cooled to 72° F. We might compare this ripening of starters to the growth of a field of corn where so few weeds exist that they are scarcely noticed and have no undesirable effects on the high grade of the crop produced.

Preparation of Mother Cultures. Some uniform container for mother cultures must be selected. This container should, preferably, be one with a cover which fits over the entire pouring mouth of the container. The container should be glassware so that it may be easily and thoroughly cleaned. Quart milk bottles with metal covers are quite suitable. Fruit jars with glass covers are also satisfactory. Place the selected milk in the jars, filling them about two-thirds full. Some oxygen in the jar seems important for best development. The jars should be well cleaned, rinsed, and dried before filling. Heat the jars in a water bath to 180° to 190° F. and hold for at least one-half hour. A longer time may be advisable if results seem unsatisfactory. The water in the bath should be at least level with the milk in the bottles. This bath should be provided with a cover so that the steam will heat the top of the bottles. A bottle containing water with an insert thermometer should be set in with the milk bottles, preferably with the thermometer protruding through the bath cover so that temperatures may be observed without removing the cover. Such an apparatus can be made and installed by a local plumber or tinsmith. Steam and water pipes should lead in, and an overflow should be provided.

Frequently three or more transfers from a new culture are required before normal growth is attained. This period of readjustment to normal growth depends on the delay in starting a new culture. The liquid laboratory cultures should be used within a ten-day period if good results are to be obtained. (See Fig. 52.)

After the jars of milk have been properly heated and cooled to 72° F., they are ready for inoculation. Using a sterile pipette, transfer a suitable amount from selected starters on hand. The amount required (usually 0.25 to 1.0 per cent) varies somewhat, depending on the vitality and previous handling of the culture. The rate of development of starters is regulated by varying the amount

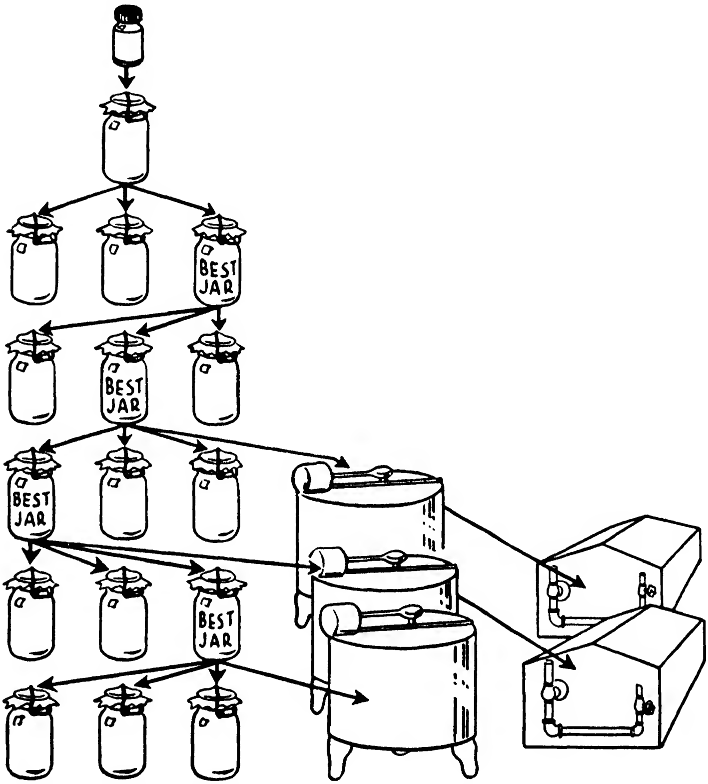

FIG. 44. Steps in the propagation of starters. From Cornell Extension Bull. 179 and Chris Hansen Co. Bull., "Starters and Cultured Buttermilk."

of inoculation rather than the temperature of holding. Daily transfers are quite essential if good active starters are maintained.

The steps in the propagation of starters, as illustrated in Fig. 44, may be outlined thus:

A. Entire contents of bottle of culture is added to ⅔ quart of thoroughly pasteurized milk. *Do not remove the cap* from the bottle of culture until just before using.

B. Extreme care should be taken to pasteurize or sterilize milk thoroughly for the first propagation, for it is at this stage that contamination often occurs. Powder culture is thoroughly dissolved by swirling several times during the first five hours. *Incubate the first propagation at* 80° F. Culture is propagated at 70° to 72° F. Best results will be obtained by propagating the culture as soon as it has set up into a smooth curd. However, most starter makers inoculate fresh jars of milk late in the afternoon and allow for coagulation during the night. The culture, therefore, is usually cooled to at least 50° F., and preferably below, and kept cold between the time it coagulates and the time it is used for inoculating. Care should be taken not to break the curd during the process of cooling.

C. Three jars of milk are inoculated with ten drops to one teaspoonful of the curd from the first propagation. Usually each jar is inoculated with a different percentage of the mother culture. The second and succeeding propagations of both liquid cultures and powder cultures are incubated at 68° to 72° F., 70° being a very common temperature. Usually about ½ to 1 teaspoonful (3.5 to 7 cc.) of starter will coagulate the milk into a smooth, viscous curd in 12 to 14 hours.

D. The best culture of the three jars from the second propagation is selected by noting the curd and other qualities. Discharge the top layer of all jars and pour samples of each jar of culture into cups for tasting. Never taste the culture by drinking from the jar in which it is carried. The best culture is used for making starter. Most starter makers use an amount of culture which will coagulate the larger volume of milk in 12 to 14 hours. The starter is always inoculated at 70° to 72° F. If a large number of jars of mother starter are carried at a time, the best jars may be selected and used for inoculating the large batch of milk in the starter can, as diagrammed. This eliminates intermediate propagations between the mother culture and starter.

E. The best culture is selected and inoculated into jars and the remaining portion of it used for making starter as described above. When the starter has set up into a smooth curd having an acidity of 0.05 per cent less than that desired, it is cooled with a minimum amout of agitation to 50° F., and preferably lower. The process of cooling should always be commenced before the final acidity decided upon by the starter maker is reached. If this is not done, the starter is likely to become overripe before it is cooled to a point below which there is no further acid development by the bacteria.

F. Where very large batches of starter are required, a starter may be built up as diagrammed. However, the smaller amount of starter will usually fill the requirements of dairies and is used for ripening cream, making buttermilk, or purposes of similar nature.

First Transfers from Laboratory Culture. Commercial or laboratory cultures carry instructions for use. These should be carefully followed. The entire contents of a package of commercial culture is used in the amount of milk specified by the laboratory which supplies the culture. The use of a portion only is unwise because (*a*) it may become contaminated when first opened, (*b*) it will probably be too old for good results if retained for use a second time, and (*c*) the commercial laboratory can assume no responsibility if poor results follow.

Incubators. Creamery supply houses can furnish suitable incubators for starters. They are thermostatically controlled and usually control temperatures within a 2° or 3° range. An electric-light bulb serves as a suitable heating unit, although small resistance coils may be used. It is quite necessary to have an insulated box to avoid frequent changes in temperature and to maintain greater constancy. These boxes must be located in the refrigerator or other room where temperatures remain below 70-72° F. (Fig. 53.)

Homemade incubator boxes, properly insulated, may be used with good results if the operator has good judgment. A drainable water compartment is provided and the jars should preferably be placed in the water on a shelf, or in a suspended basket. By this arrangement a sufficient quantity of tempered water will hold the temperature close to 72° F.

Maintenance of "Balance" in Starters. The 72° F. temperature has long been standard. If there is much variation from this temperature a starter may easily "get out of balance." A starter is out of balance when the *S. lactis* organisms are present in too great a proportion as compared to the *citrovorus* organisms, or vice versa. The starter may be very sour and develop but little flavor, or the flavor may be undesirable because of delayed acid development by *S. lactis*. Sometimes this balance is not easily restored and a new starter is required. Hammer [2] indicates that the *S. lactis,* or principal acid producers, constitute from 90 to 99 per cent of the total number of organisms and that the *citrovorus* types usually range from 1 to 10 per cent of the total number. The percentage of *S. lactis* organisms may drop as low as 75.

Factors Affecting Growth of Starters. The accompanying graphs, *A* and *B*, serve nicely to explain two of the factors affecting starter growth. The list of factors is:

1. Temperature.
2. Time.
3. Amount of inoculation.
4. Vitality and activity of organisms.

Preparation of Bulk Starter. Large quantities of starter for use in the creamery are made by inoculating properly prepared milk with the "mother" cultures which have been propagated in the glass jars. Starter cans are employed for this purpose, although sometimes common coil vats are substituted. Starter cans are much more suitable because of ease of cleaning. A starter can should not be used for purposes other than starter making because some contamination of starters may result.

Stainless-steel starter cans or glass-lined vats are much more suitable than tinned copper. This is particularly true if the starter is to be held long after coagulation. Tinned-copper cans are too frequently kept in use after the tinning is worn and bare copper may be exposed. Solution of copper in the starter may occur and the flavor of cream in which it is used may be adversely affected.

Although extreme care is frequently not practiced in the making of bulk starters, nevertheless it must be pointed out that carelessness in the making of bulk starters is frequently a cause of unsatisfactory results. The creamery man is advised to be careful in all details and to follow the procedure used in preparing mother cultures in so far as possible.

Fabricius [3] indicates that starter cans are not entirely satisfactory. For fine bulk starter, he recommends the use of ten-gallon cans. These cans are placed in a wooden tank with steam and water connections. Pasteurization, cooling, and ripening all take place in this tank. Temperature control is very important and is more exact with this method. Fabricius states that this is particularly true in summer and that starter cans may be very satisfactory

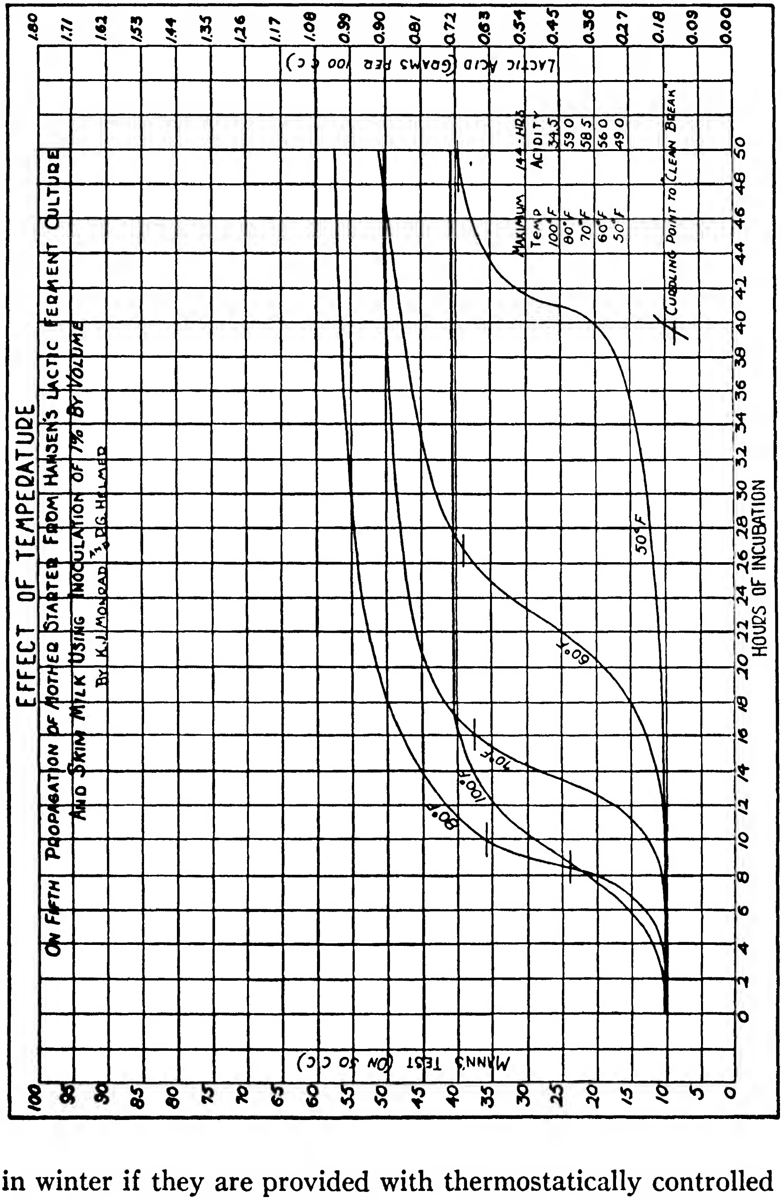

FIG. 45. Graph A. Effect of setting temperature of starter milk on its rate of souring. Courtesy Chris Hansen's Laboratory, Inc. From "Starters and Cultured Milk."

in winter if they are provided with thermostatically controlled heating units installed in the starter-can jackets. Only well-tinned cans or aluminum cans should be used in the tank method. They should be loosely covered to prevent contamination from the air.

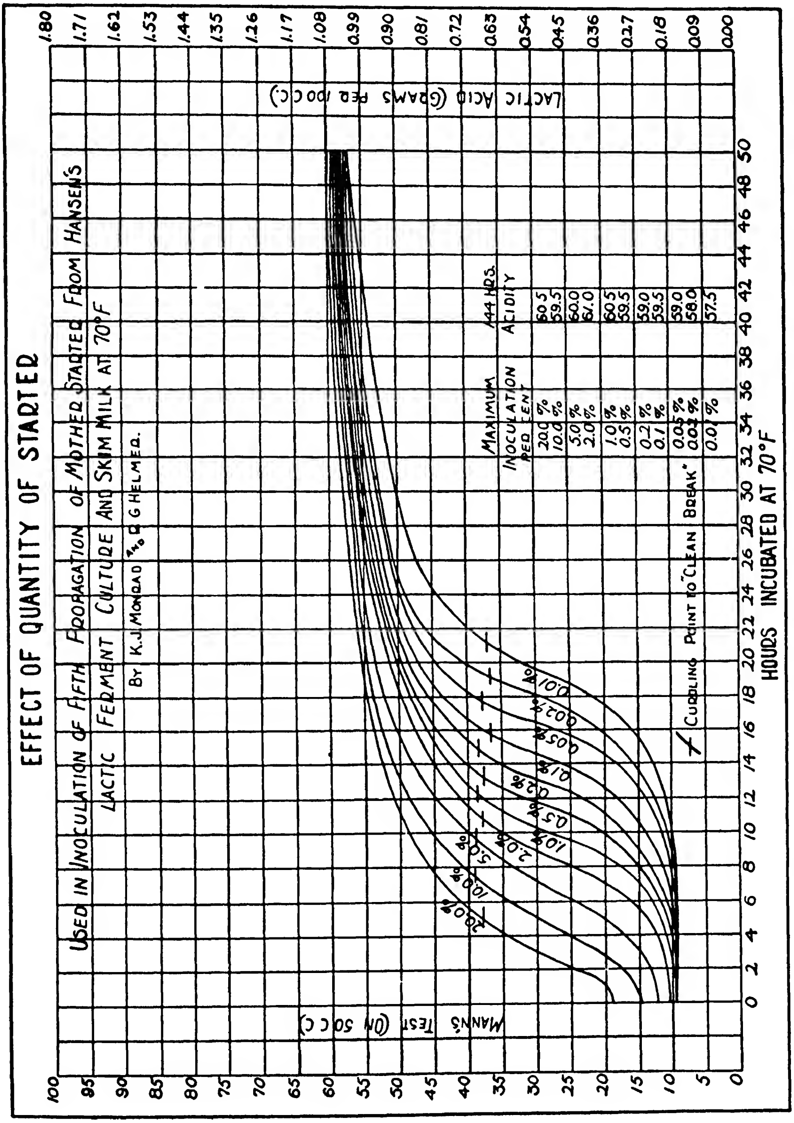

FIG. 46. Graph B. Effect of quantity of starter or amount of inoculation on the rate of souring of starter milk. Courtesy Chris Hansen's Laboratory, Inc. From "Starters and Cultured Milk."

Figures 45 and 46 illustrate two of the most important factors controlling the development of starters. Additional fundamental considerations are the previous treatment of the culture and its age. Both these have much to do with the rate of acidity development in cultured milk.

Amount of Inoculation for Bulk Starters. Recent studies at the Iowa Experiment Station [3] indicate that 1 to 2 pints of mother culture per 10 gallons of bulk culture should be used. This exceeds the amount used by most operators. It causes more rapid ripening and allays possible germicidal effects of the milk. In addition, the starter will develop sufficient acid in less time, and favor flavor development by the citrovorus organisms. The Iowa Station ripens

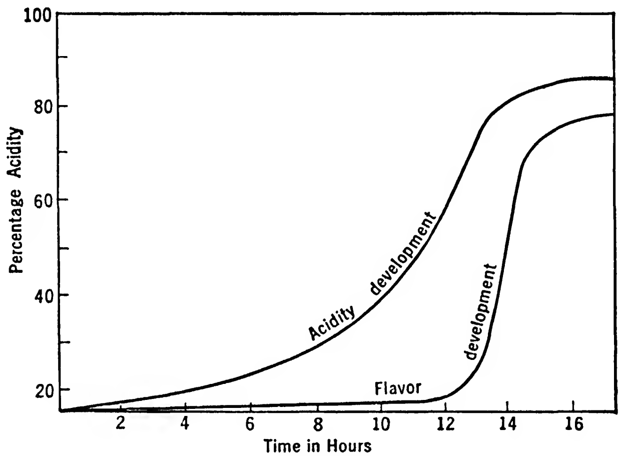

FIG. 47. Theoretical graph illustrating the retarded flavor development as compared to the acidity development in starters. Starters should be cooled and held after coagulation to allow time for flavor development. Vigorous agitation and air incorporation are beneficial to flavor development in bulk starters.

to 0.85 to 0.90 per cent acidity, cools to a low temperature, and allows considerable time for flavor development before use. This is quite in accord with present practices of using larger amounts of starter to impart flavor and not to cause ripening of the cream.

It is important that bulk starter should contain plenty of desirable flavor and aroma. These are lacking to some extent in a freshly coagulated starter. Shortly after coagulation of the milk it is desirable to cool the starter and allow several hours for flavor development, as indicated in Fig. 47.

Kinds of Milk for Starter. Whole milk, skim milk, and powdered skim milk are used for starters. The kind of milk might be said to be a fifth factor affecting starter growth. Only the best quality of any of the three media named should be used, and, when this fact is carefully considered, there is but little difference in the rate of growth of the organisms. Whole milk is preferable because it is usually fresher and can be selected with greater care. Many creameries which have uses for sweet cream, skim the starter milk and use the fresh skim milk for starter making.

Defects in Starters: Overripening and Underripening. Poor starters result from the use of poor milk or faulty technique in making the starter. The quality of milk has just been discussed. Poor technique may result from carelessness or ignorance at any stage of the operations. The milk must be properly heated, as previously described. All jars, pipettes, etc., must be as nearly sterile as possible. A well-planned routine which has proved efficient must be followed with no short cuts.

A common fault in carrying starters is overripening. The right amount of inoculation should be determined and used. This amount is best discovered by judging the time required for coagulation. A starter set at 5 P.M. should be coagulated by 10 o'clock the next day. It is best to set the starter near the close of the day's operations. This will result in the coagulation of the starter the next morning when the operator is at hand to agitate and cool it to a temperature of 45° F., or less, in order that further acid development will be minimized. Milk set at 72° F. will curdle at about 0.60 per cent acidity. Within an hour the coagulum should be mixed and cooled. Several hours' holding at reduced temperatures permits the flavor-producing organisms to do their part. With the growing practice of using larger percentages of starter in cream and decreasing or omitting entirely a ripening period, it becomes more necessary that the starter have pronounced flavor.

Overripe starters develop a sharp acid taste and are not so desirable as those in which the acidity does not exceed 0.80 per cent. High-acid development greatly retards the activity of the starter organisms and may greatly reduce their vitality.

Low-acid starters are slow to develop flavor and are not so suitable. Starters incubated at low temperatures may have little more than sour-milk flavor, or they may be bitter and useless. Incubation at higher temperatures may favor overripeness and may also permit resistant milk organisms to develop to the point of damaging the starter. A good starter, as judged in the mother culture jar, has no appearance of gas bubbles and shakes up to a smooth, creamy consistency. Hunziker suggests the following score card:

STARTER SCORE CARD

(From service bulletin, Chris Hansen's Laboratories, Inc., "Starters and Cultured Milk")

Name.................... Date.....................

	Score		*Description*
	Perfect	*Actual*	
Aroma	20	..	Clean, pronounced, pleasant, no taint
Flavor	40	..	Clean, pronounced, snappy, free from yeasty, cheesy, curdy and other off flavors
Body	20	..	Smooth, soft, creamy, no gas holes, no whey
Acid	20	..	0.7 to 0.8 per cent acid
	100		

The card used at the South Dakota State College is:

STARTER SCORE CARD

Contestant No................. Date.......................

	Perfect Score	*Judge's Score*	*Description*	
			Desirable	*Judge's criticism*
General appearance	5	..	Smooth uniform	
Body and texture	30	..	Smooth velvety	
Flavor and aroma	60	..	Full, clean, mild	
Acidity	5	..	0.70 to 0.80 per cent	
	100	..		

It will be noted that flavor and aroma on both cards are rated as 60 per cent. Acidity is given 20 on one card and 5 on the other. This might be a controversial point. The important considerations, however, seem to have been given equal rating on the two cards.

Use of Citric Acid and Citrates in Starters. Citric acid is a normal constituent of milk. The percentage listed by various authors varies from 0.07 to 0.40 per cent with an average of about 0.18 per cent. The wide variation in percentage is probably due to the several methods used in analysis. Citric acid in milk is present in the form of citrates.

It is known that the two flavor-producing organisms in butter cultures utilize citrates or citric acid in their growth. The intensity of desirable flavor in these cultures or starters is dependent to a considerable extent upon the citrate content of the milk used. Templeton and Sommer in 1929 [1] show that the volatile acidity of cultures was increased 50 per cent by the use of either citric acid or sodium citrate. In the judging of these starters practical butter and starter judges preferred those to which citric acid or sodium citrate had been added.

Again Templeton and Sommer in 1935 [4] show that citric acid or sodium citrate, added either to the cream or to the starter or both, tends to produce more desirable flavor in the butter. These substances were added either to the starter milk or to the cream in amounts not exceeding 0.20 per cent. The authors state that there is evidence that a higher volatile acidity may be indicative of a high diacetyl and acetylmethylcarbinol content of the culture and of the butter made with the use of such culture. The butter scores were improved by the addition of these chemicals to the cream or to the starter.

Artificial Butter Flavors. Since 1933 several commercial butter flavors have been offered to the trade. In general, they contain the two important flavor substances of starters, viz., diacetyl and acetylmethylcarbinol. Their use in flavoring butter was ruled illegal on November 22, 1933, in an order sighed by W. G. Campbell, chief of the Food and Drug Administration of the United States Department of Agriculture. Most state laws define butter in practically the same way as the federal government. Interpretations of state pure-food laws, therefore, are in line with those of the federal government. Correspondence with officials of dairy and food departments of the ranking butter-producing states indicates that there is lack of a satisfactory laboratory test to determine the presence of added butter flavors. The flavor substances produced by starters are identical with many commercial butter flavors, and it therefore becomes very confusing to try to determine the presence of commercial flavor extracts. Hammer [5] gives a method of determining the approximate amount of these flavor substances in starters by a color intensity method. In judging these starters, the degree of flavor correlated quite closely with the color test. Hammer [6] states, however, that no tests appear to be satisfactory for detecting artificial flavors added to butter. If excessive amounts were used, it might be shown by use of the creatine test that the amount present in butter was greater than the normal amount present when starter only is used. He suggests that the test probably should be used on the serum of butter.

The ruling by the federal government against the use of artificial flavors in butter is entirely logical. However, the use of these substances in the future is unpredictable, especially if butter should be marked in compliance with labeling and branding laws. It is the author's opinion that artificial flavors in butter frequently result in harsh unpleasant flavors. A good comparison might be the flavor of ice cream as flavored with artificial vanilla against ice cream flavored with pure vanilla bean extract. The latter flavor is far smoother and more pleasing to most consumers.

CREAM RIPENING

Definition. Cream ripening consists of the souring of cream with cultures or starters with the consequent development of desirable flavors and aroma in the cream. The degree of souring is predetermined, and uniformity in ripening is one of the essentials of success.

Present Trends in Ripening. The tendency in cream ripening has been to control the process more carefully and to ripen to lower acidities. In fact, much recent experimental work on the keeping quality of butter indicates that ripening of cream may be quite generally replaced by the use of large amounts of good starter. It is quite interesting to note that, for years, cream vats were referred to as ripeners. The term has become rather old fashioned, and the process of ripening cream has changed radically. Some large creameries neutralize cream to 0.20 per cent acid, add sufficient starter to raise the acidity to 0.25 per cent, and do not ripen at all. If cream is ripened beyond 0.30 per cent acidity, the keeping qaulity of butter decreases as the acidity of ripening increases. When special markets or special trade demands higher-flavored butter it is quite logical to satisfy such demand. For example, the Jewish trade in a number of cities, especially in New York City, calls for uncolored, unsalted, ripened-cream butter. Such butter, being poorly adapted to storage, is produced for prompt consumption. It is often considerably above 80 per cent in butterfat but sells for a higher price, and frequently nets the manufacturer slightly more money than ordinary salted butter.

Ripening Cream for Unsalted Butter. Although salted butter must be kept below a certain acidity limit for good keeping quality, unsalted butter on the contrary requires some acidity for improved keeping quality. In the absence of salt as a deterrent to microbiological action, acidity does control and inhibit certain undesirable fermentations, such as those which develop in neutral or slightly alkaline media. Acidity, however, favors the development of mold in unsalted butter, and very strict sanitary methods are required in its manufacture. Frequently creameries which have started making unsalted butter were compelled to abandon the work because their methods were not sufficiently careful throughout and the butter arrived on the market in a moldy condition. The ripening of cream for unsalted butter may be carried to the point of 0.40 to 0.45 per cent acidity in the cream.

A second purpose in ripening unsalted butter is elimination of the very flat taste which it has unless made from cream with some acidity. The butter is thus made more palatable. Consumers of unsalted butter, primarily the Jews, are accustomed to the ripened flavor and no doubt would object if it were lacking. We may say, therefore, that ripening cream for unsalted butter is good practice for two reasons.

1. Preservative effect—inhibiting growth of putrefactive organisms and others.
2. Providing additional flavor—necessary because of the lack of salt.

A discussion of unsalted butter should take account of its not being intended for storage. It does not have keeping quality. It must be consumed within a few weeks after it is made. It must be well refrigerated (0° F., or lower) and it cannot be subjected to temperature above freezing even for short periods without serious loss in quality or mold growth.

Unsalted butter usually sells at a higher price than salted:

1. It is for a special market.
2. It requires extra work and expense in manufacture.
3. It frequently contains a higher percentage of fat.

4. Losses may be incurred as a result of mold or flavor deterioration.

Differences of Opinion on Ripening. There are, in a sense, two groups of leaders in the butter industry with divergent opinions with respect to the use of starters in cream ripening. In Iowa, many

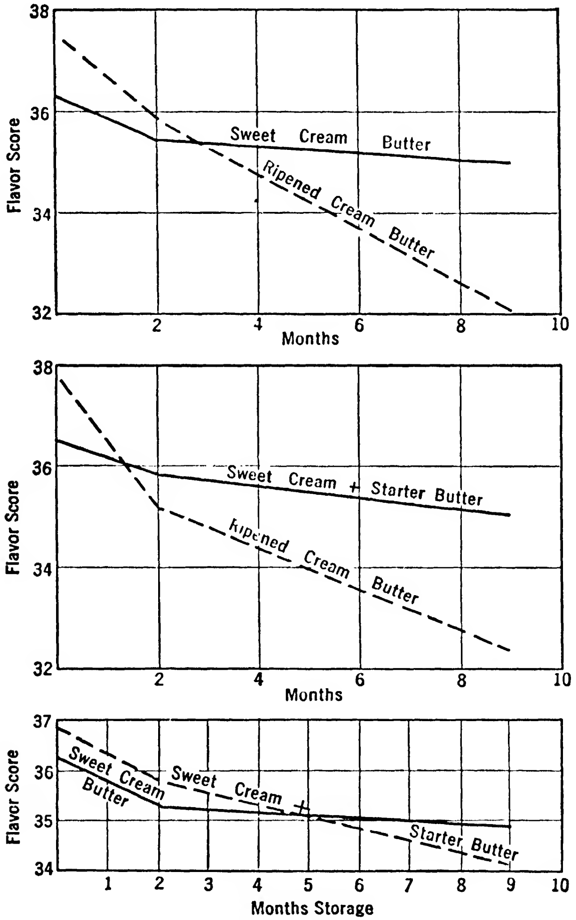

FIG. 48. The influence of cream acidity and method of using starter on the keeping quality of butter. From Iowa Bull. 207, 1922, M. Mortensen.

dairy leaders and creamerymen believe in the use of starters. In Minnesota there is quite a trend toward the production of unripened sweet-cream butter. Excellent butter is produced in both of these leading butter-producing states. It is very probable that the effects of cream ripening cannot be determined so completely where so great a percentage of high-grade cream is produced. Sweet cream may be ripened to higher acidities than sour and second-grade cream and still possess very good keeping quality. Mortensen[7] shows that butter made from cream ripened to 0.63 per cent buttermilk acidity stored well for two months, but thereafter was inferior to sweet-cream butter and to butter made from unripened cream to

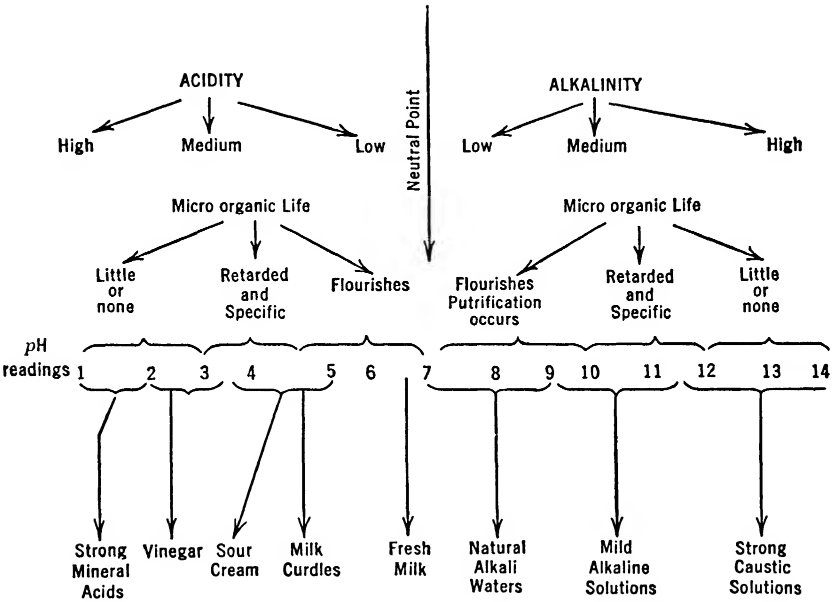

FIG. 49. Acidity and alkalinity. Relative *p*H. Relation to bacterial growth and to some dairy-plant operations.

which starter was added. He states also that most commercial butter is consumed within a two-month period. The accompanying graph shows clearly the results of Mortensen's work. Mortensen[7] studied various methods of using starter and compared the keeping quality of this butter with that made from sweet cream without starter. Some of the results of his work are illustrated in Fig. 48.

Cream, Butter, and Serum Acidities: *p*H of Butter and Keeping Quality. Hunziker and Cordes[8] studied the acidity of butter, cream, and buttermilk with relation to the keeping quality of butter. They found considerable differences in the acidity of butter, depending upon several factors. One important factor was cream acidity before processing. Sweet cream, compared with the same cream ripened to acidities as high as 0.80 per cent, and neutralized back to the same churning acidity as the sweet cream, showed consistently higher acidities in the butter from the unneutralized cream. These experiments indicate that butter acidities fail to serve as an index to the cream acidities or serum acidities at the time of churning, and therefore are not important in predicting keeping quality. Butter made from neutralized cream, with butter acidities corresponding to a *p*H of 5.7 or lower, may have poorer keeping quality, but butter made from sweet cream and churned at the same cream acidity may still have very good keeping quality.

Figure 49 has been prepared with the hope of facilitating an elementary conception of the relation of *p*H and titratable acidity. An attempt is made also to correlate this understanding with some dairy-plant experiences, such as milk curdling, making washing-powder solutions, the growth of microorganisms, etc.

***p*H of Commercial Butter.** Parfitt [9] studied the *p*H of commercial butter at the Purdue Station. Of 468 samples made in 65 creameries, his results were as follows:

*p*H of Commercial Butter

*p*H of Butter	Percentage of All Samples	*p*H of Butter	Percentage of All Samples
Above 7 00	10.03	6.00 to 5.51	18.58
7.00 to 6.51	25.42	5.50 to 5.01	4.06
6.50 to 6 01	38.23	Less than 5.00	3.63

Winter butter showed higher acidities than butter at other seasons. Some creameries were able to control the *p*H of butter within narrow limits; others were not.

It will be noted that 63.65 per cent of all samples fell in the range of *p*H 6.01 to 7.00.

Considering these results of Parfitt and of Hunziker we might represent the range in butter of good keeping quality as from *p*H 6.5 to 7.00, the latter referring more particularly to neutralized-cream butter and the former referring more particularly to sweet-cream butter, or sweet cream ripened to 0.25 per cent acidity at churning.

It is difficult to translate *p*H readings into terms of acidity, which are more readily understood by the majority of creamery operators. Hunziker states that butter made from cream with churning acidities of 0.25 per cent had usually less than 0.06 per cent butter acidity.

***p*H Readings (Hydrogen-ion Concentration), Acidity, and Alkalinity.** The facts and explanations regarding the relation of these subjects are intensely involved. Only a very elementary explanation will be attempted here.

Briefly, it may be stated that acidity measurements indicate ionized H ions and part of the ionizable H ions. *p*H measurements indicate only the ionized H ions (also OH or hydroxyl ions on the alkaline side).

These facts are explainable on the basis of dilution of the sample being titrated to determine the percentage of acid. Dilution changes the concentration and the extent of ionization. Other factors affect ionization, but their discussion is too involved for our purpose. *p*H measurements are most simple in true solutions but are not difficult in other media if water is the continuous phase and the solution or emulsion is not excessively concentrated. The determination of either acidity or *p*H in butter requires special procedures because of its density and the fact that butterfat is the continuous phase. Hunziker, Cordes, and Nissen [10] devised a method for *p*H determinations in butter.

Although the creamery operator has used acidity tests on dairy products, it may be that *p*H measurements may become standard practice in the future. It has been definitely determined that the latter are more exact. Since the activity of microorganisms is more accurately determined by *p*H than by common acidity determinations, dairy-plant control is more definite when *p*H measurements are made. In the neutralization of cream and the control of keeping quality in butter, *p*H determinations are assuming a major role in experimental work, and it is probable the practical plant operator may soon be using this more exact method.

White, Trimble, and Wilson [11] studied the keeping quality of butter made from cream with churning acidities of 0.14 to 0.45 per cent. Lots of the same cream were divided and treated in various ways. The range of conditions and treatments covered those commonly found in creamery practices, except that no cream acidities exceeded 0.45 per cent before neutralizing.

AVERAGE SCORES OF BUTTER WHEN FRESH AND AFTER DIFFERENT PERIODS OF STORAGE (SEVEN CHURNINGS AT EACH ACIDITY)

(White, Trimble, and Wilson, Technical Bull. 159, U. S. Department of Agriculture)

Cream acidity when churned	Fresh	After 4 months at 30° to 50° F.		After 8 months at 0° F.		After 12 months at 0° F.		After 12 months at 0° F. and 3 weeks at 30° to 50°	
	Score	Score	Decrease	Score	Decrease	Score	Decrease	Score	Decrease
Per cent	Points	Points	Points	Points	Points	Points	Points	Points	Points
0.15	91.10	89.21	1.89	90.55	0.55	89.67	1.43	89.50	1.60
.22	91.02	88.93	2.09	90.58	.44	89.58	1.44	88.92	2.10
.25	91.29	88.86	2.43	90.69	.60	89.83	1.46	89.08	2.21
.28	91.38	88.89	2.49	90.65	.73	89.25	2.13	88.67	2.71
.31	91.14	88.71	2.43	90.38	.76	88.58	2.56	87.92	3.22

Relation of Churning Acidity and Stored Butter Scores. White, Trimble, and Wilson also studied and tabulated the results of the 1925 and 1926 cold-storage contests of the National Creamery Buttermakers' Association. All entries where the cream received was above 0.2 per cent acidity were excluded, and only those entries were used which gave all the data needed. The storage period for 1925 was about 5 months, and that for 1926 was somewhat less.

With fresh butter, lowest scores were on the butter from cream of lowest acidity which had no starter.

After storage, the butter scores were very close in those samples with cream acidity up to 0.3 per cent. The 0.31 to 0.35 per cent cream acidity group had about ½ point lower scores, and the 0.36 to 0.45 per cent cream acidity group had about 1 point lower scores.

The following table shows the results of their studies:

AVERAGE SCORES OF BUTTER IN THE NATIONAL CREAMERY BUTTERMAKERS' ASSOCIATION COLD-STORAGE BUTTER CONTEST, 1925 AND 1926 (292 ENTRIES)

(Technical Bull. 159, U. S. Dept. of Agriculture)

Acidity of cream when churned	Samples	Average acidity when—		Average score of butter			Samples not decreasing in score during storage		Samples scoring 94 or higher after storage	
		Received	Churned	Fresh	After storage	Decrease				
Per cent	Number	Per cent	Per cent	Points	Points	Points	Number	Per cent	Number	Per cent
0.20 or less*	60	0.169	0.172	92.83	92.60	0.23	24	40.0	3	5.0
.20 or less†	74	.153	.186	93.28	92.77	.51	20	27.0	7	9.5
.21 to 0.25	77	.167	.231	93.16	92.52	.64	22	28 6	6	7.7
.26 to .30	52	.165	.287	93.43	92.59	.84	10	19.2	4	7.7
.31 to .35	17	.182	.331	93.11	92.08	1.03	3	17.6	0	0.0
.36 to .45	12	.164	.401	93.21	91.45	1.76	2	16.6	0	0.0

* No culture. † Culture used.

Data from the work of White, Trimble, and Wilson have been transformed into graphs which appear in Fig. 50. They conclude in part thus:

> Butter made from cream with an acidity as high at 0.31 per cent (churning acidity) may be expected to keep well for as long as 8 months when stored at a temperature of 0° F. or lower. (See Fig. 50.) There appears to be no advantage, however, in making butter for storage from cream with an acidity as high as 0.31 per cent. Ripening cream with a lactic culture even to low acidities improves the score of the butter when fresh, but the improvement is usually lost during storage.

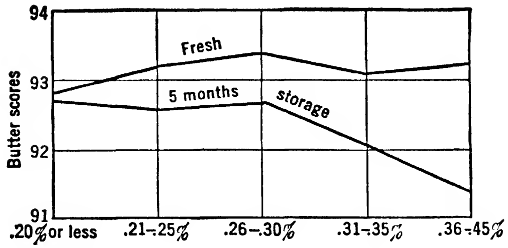

FIG. 50. Churning acidity of cream. Graphical presentation of the differences in butter scores when fresh and after 5 months' storage at 0° F. Attention is directed to a slight increase in score with slightly higher churning acidities in fresh butter. The prime consideration is keeping quality. Note the more marked decrease in scores on storage as churning acidities increased. From White, Trimble, and Wilson, U.S.D.A. Tech. Bull. 159, 1929.

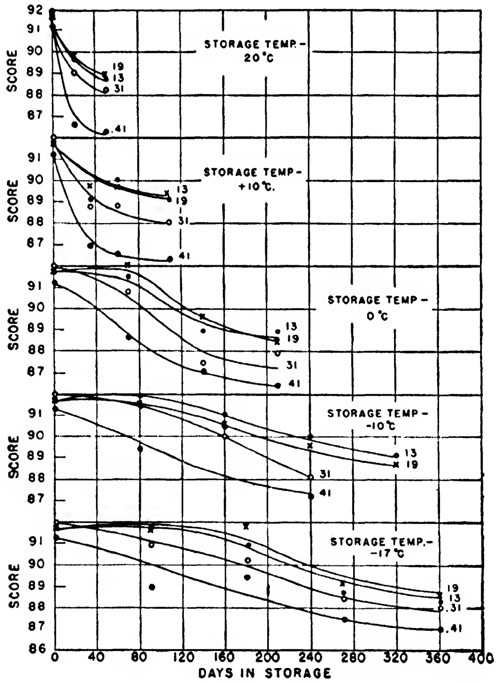

FIG. 51. The influence of churning acidity and storage temperature on the keeping of butter. From Holm, Wright, White and Deysher, "The Keeping Qualities of Butters," *Jour. Dairy Sci.*, Vol. 21, p. 385, 1938.

Figure 51 is reproduced from the work of Holm, Wright, White, and Deysher. Fresh sweet cream was pasteurized and brought to acidities ranging from 0.20 to 0.40 per cent and then churned. Samples were stored at five different temperatures and for various periods as indicated by the graph. In addition to butter scores, peroxide values, time of bleaching, and two dye-reduction tests were recorded. In general the chemical changes occurring in butter of less than 89 score were greater than the scores of butter indicated. Butter scores are of greater commercial significance since edibility is important in the sale of butter. Churning acidities of cream of 0.30 per cent or more were less desirable than lower acidities from the standpoint of butter-keeping quality.

Whittier and Trimble[12] studied cream and butter acidities in an effort to find some yardstick to aid in predicting keeping quality of butter. Twenty samples of southern butter were analyzed for acidity. Four samples were made from sweet cream and 16 from partially neutralized cream.

The sweet-cream butter showed acidities below 0.025 per cent, and the partially neutralized samples showed acidities above 0.05 per cent. Their table follows on page 184.

They concluded:

1. Butter made without starters from normal cream containing less than 0.25 per cent of titratable acid will contain less than 0.025 per cent apparent lactic acid.
2. Butter made without the use of neutralizing agents from normal sour cream containing more than 0.40 per cent of titratable acid will contain more than 0.10 per cent apparent lactic acid.
3. Butter made from sour cream, neutralized to approximately 0.20 per cent titratable acidity, will contain more than 0.05 per cent apparent lactic acid.
4. Dilution of cream with water or sweet skim milk or washing butter with alkaline water will somewhat decrease the percentage of lactic acid in butter. Such procedures are not likely to be encountered commercially since they injure the flavor and texture of the butter.
5. Storage of butter, even at temperatures considerably higher than those customarily used for butter storage, has no effect on the percentage of apparent lactic acid present.

Relation of Cream Acidity, Churning Acidity, and Butter Acidity

Sample	Titratable Acidity of Cream		Apparent Lactic Acid in Butter
	Before Neutralization	When Churned	
1R	0 55%	0.28%	0.063%
2R	0.80	0.15	0.051
3R	0 60	0 25	0 059
4R	0.70	0.24	0 075
5R	0.80	0.22	0 071
1N	0.65	0 25	0.068
2N	0.60	0.23	0.067
3N	0.65	0.24	0.084
4N	0.82	0.24	0.074
5N	0.73	0 23	0.061
1K	0.78	0.23	0.057
2K	0.56	0.25	0.062
3K	0.72	0.28	0.057
35B	0.16	0.16	0.023
37B	0.14	0.14	0.011
38B	0 14	0.14	0.020
39B	0.16	0.16	0.021
40M	0.84	0.27	0.082
41M	0.84	0 27	0.081
43	1.30	0.24	0.127

The advantages of ripening or addition of cultures without ripening:

1. Possible higher score on fresh butter from good cream.
2. Higher scores on fresh butter from lower-grade cream.
3. More uniform flavor and quality.
4. Selling for more money to special trade, as the Jewish trade.

The disadvantages of ripening or addition of culture without ripening:

1. Lowered keeping quality on all grades of cream unless churning acidity does not exceed 0.30 per cent.

2. Expense of cultures, starter milk, equipment, and time required.

Literature Review. The following review is from Bulletin 207 of the Iowa Station:

In 1859 Henry Ward Beecher criticized the quality of market butter and recommended that cream be churned sweet.

In 1886 the New York State dairy commissioner stated that the best-flavored butter is made from sweet cream. If acid fermentation is allowed to go too far it will lower the grade of butter.

In 1889 the West Virginia Experiment Station reported that the college creamery had established a demand for sweet-cream butter. (For references on these reports, see U.S.D.A. Technical Bulletin 159-1929.)

In 1890, at the Iowa Station, Patrick compared sweet and sour cream for buttermaking.

In 1893 Patrick, Leighton, and Heilerman found that sweet-cream butter had superior keeping quality compared with ripened-cream butter.

In 1904 Dean compared sweet-cream butter and butter from cream to which 20 to 30 per cent starter had been added. Butter made from cream to which the starter was added was superior in quality.

In 1906 Gray found that butter made from cream arriving in good condition kept well at —10° to + 10° F. and when removed from storage remained quite fresh. Butter from cream which arrived sour also kept well at the same temperatures, but deteriorated rapidly upon removal from storage.

In 1907 Shutt and Sharon found sweet-cream butter distinctly superior in keeping quality and buttermilk fat losses no greater than those in ripened-cream churning.

In 1909 Larsen, Lund, and Miller tested commercial butter for acidity and found the acid test a help in predicting the keeping quality of butter.

In 1909 Rogers found that butter which became fishy during storage was made from high-acid cream. Cream acidified with lactic and acetic acid also became fishy. However, cream of high acidity does not uniformly become fishy.

In 1912 Rogers, Thompson, and Kiethly found that butter made from cream with acidities below 0.3 per cent usually scored above 90, while butter from cream with higher acidities usually scored below 90. Butter was stored at 0° F. and 20° F. The higher storage temperature was much less satisfactory. The deterioration in ripened-cream butter at 0° F. was 4 times as fast as that of the sweet-cream butter. Even at 20° F. the sweet-cream butter was definitely better during and after storage.

In 1916 Ruehle found sour-cream particularly likely to produce fishy flavor in butter.

In 1916 Dyer found that there were slow oxidation changes in the non-fat substances of the buttermilk and that the flavors in butter suffered in direct proportion to the amount of acid in the cream.

In 1916 Potts made recommendations for making and marketing southern butter. He stated that lower acidity in cream makes better butter and butter which will hold up better in storage. He recommended that butter for storage be made from pasteurized sweet cream.

In 1921 Ibsen in Denmark recommended comparatively high degrees of acidity in warm weather to overcome cheesy flavors in butter. Keeping qualities were not tested. He also recommended thorough washing of the butter. Orla Jensen found that cheesiness was associated with the serum in the butter and that yeasts and rod-shaped lactic acid organisms were responsible for the changes.

In 1923 Sommer and Smit [13] found the acidity of cream to be a factor in the development of fishy flavor. Part of the role of acid, in the development of fishiness, is that of hydrolysis of lecithin. The lecithin changes to dimethylamine and trimethylamine, which are the fishy-flavored substances. Acid favors the development of fishiness because:

1. It favors the hydrolysis of lecithin.
2. It favors the oxidative processes in butter.
3. Acids cause the cream to dissolve iron and copper from utensils.

In 1929 White, Trimble and Wilson [11] found butter from cream with churning acidities as high as 0.31 per cent to possess good keeping quality for 8 months stored at 0° F. They further stated that there is no advantage in making butter for storage from cream as high as 0.31 per cent. Ripening improves the score of fresh butter from good cream, but the improvement is usually lost during storage.

In 1934 Hunziker [14] stated that the New Zealand butter industry had concluded that cream with low acid content, and without the use of culture in any form, yielded the best results under their conditions. The use of pastures during the entire year gave the butter a June-feed flavor and provided flavor without the use of starter. They churned at cream acidities not above 0.2 per cent. In Aus-

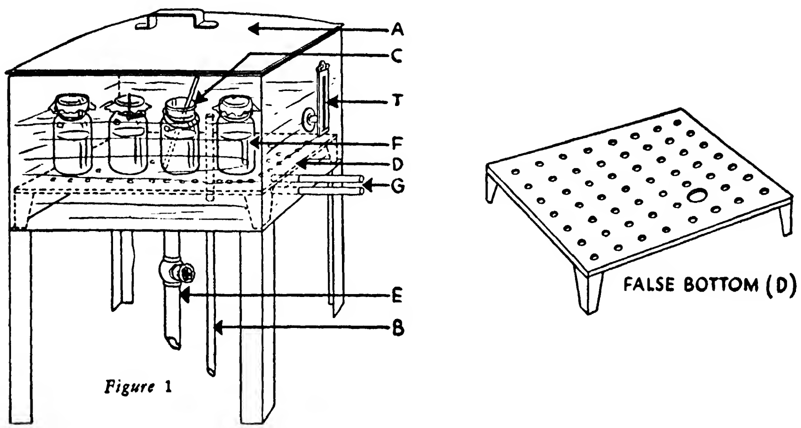

FIG. 52. Pasteurizer for quart jars of milk.

A. Tight fitting cover . . . may be hinged or plain.
B. Overflow pipe . . . can be connected at bottom or side.
C. Starter jar used as temperature indicator.
D. False bottom may consist of perforated iron plate and, in addition, perforated metal baskets made so that one starter jar will fit snugly in one of the baskets.
E. Drain pipe.
F. Starter jars.
G. Cold water and steam pipes. May enter pasteurizer separately or through one connection. The water may be heated by direct steam or by steam coil. In the latter case the heating will not be accompanied by violent agitation of the water and noise produced by direct steam heating. Cold water may enter through one opening such as shown in the diagram; however, a better arrangement is to have it enter through a perforated pipe extending full length at bottom of vat below false bottom. This arrangement helps to reduce breakage of the starter jars by distributing the cold water more uniformly. Courtesy, Chris Hansen's Laboratory, Inc.

tralia, low acidity in the cream, high pasteurizing temperatures, and no use of starters have proved to be best for the quality of butter arriving on the London market.

In 1936 Guthrie, Scheib, and Stark [15] reported that the presence of either acid or salt in butter not containing other spoilage factors considered in the study resulted, after storage, in butter of poorer quality. They reaffirmed the statements relative to the inhibiting effects of salt and acid on bacterial growth.

Use of Starter: Status and Summary.

FIG. 53. Culture incubator cabinet with automatic temperature control. Courtesy Chris Hansen's Laboratory, Inc.

1. Starters are more safely used with sweet cream and a good grade of cream.
2. Starters produce possible higher fresh butter scores but appear to have little if any advantage in storage butter.
3. Churning acidities above 0.3 per cent are detrimental in storage butter and appear to have little advantage in fresh butter.
4. For low-grade cream, ripening appears to be detrimental; the addition of large amounts of starter without ripening produces the desired improvement in flavor.
5. Sweet cream pasteurized at high temperatures, 160° to 165° F. and without starter, produces butter of excellent keeping quality. This statement must not go unqualified. Careful sanitation is required for all equipment with which the cream and butter come in contact after pasteurizing.

Relation of Cream and Serum Acidity. Mortensen [7] in 1922 suggested a serum (buttermilk acidity) of 0.63 per cent as a limit. White, Trimble, and Wilson [11] in 1929 indicated that 0.31 per cent cream acidity is a safe limit. This corresponds to a serum acidity of about 0.45 per cent.

A third basis is advocated by the authors, viz., 0.40 per cent serum acidity.

Figures 52 and 53 show a pasteurizer and a thermostatically operated incubator for mother cultures. Similar equipment may be made in the creamery or purchased from supply houses. It should be pointed out, however, that makeshift apparatus is to be avoided. Temperature control is important.

Calculation of Churning Acidities of Cream Based on Serum Acidity Factors

	Cream		Buttermilk or serum acidity factor. Percentage	Maximum churning acidity to standardize with starter. Percentage
	Percentage fat	Percentage serum		
Indicated by Mortensen (1922)	28	72	0.63	0.453
	30	70	0.63	0.441
	32	68	0.63	0.428
	34	66	0.63	0.403
	36	64	0.63	0.403
Indicated by White, Wilson, and Trimble (1929)	28	72	0.45	0.324
	30	70	0.45	0.315
	32	68	0.45	0 306
	34	66	0.45	0 297
	36	64	0.45	0.288
Indicated by Authors (1939)	28	72	0.40	0.288
	30	70	0.40	0 280
	32	68	0.40	0.272
	34	66	0.40	0.264
	36	64	0.40	0.256

Calculations: 100 lb. cream − 28 lb. fat = 72 lb. serum.
0.63 per cent or 0.0063 × 72 = 0.4536 or per cent churning acidity of cream

QUESTIONS

1. What is meant by a starter as used in creamery work?
2. Name the organisms it may contain and state what organisms are essential.
3. State the role played by each group of organisms.
4. State the purposes of using starter.
5. Distinguish between pasteurization and sterilization.
6. Why is 72° F. established as the normal temperature for propagating starters?
7. What is meant by "a starter being out of balance"?
8. List the factors affecting the rate of growth of starters.
9. State some defects of starters and describe their causes.
10. State some factors which determine the length of time a starter may be carried and retain satisfactory qualities.
11. Aside from the legality of the question, what appear to be the results from the use of artificial butter flavors?
12. Compare present cream-ripening trends with former practices.

13. Consider cream with fat tests of 28 per cent and 38 per cent. Calculate the serum acidity in each when both lots have a cream acidity of 0.30 per cent. Which cream is probably older or less desirable from the standpoint of quality?
14. How does churning acidity of cream affect the keeping quality of butter?
15. What limit of serum acidity would you establish when considering only the keeping quality of the butter?
16. Is more cream acidity advisable when unsalted butter is made? Why?

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CHAPTER 10

CHURNING

Definition. Churning of cream, with the subsequent formation of butter, consists of agitation at suitable temperatures until the butterfat globules adhere, forming larger and larger butter masses until a relatively complete separation of fat and serum occurs. There are many factors affecting the rate and the completeness of this separation. Still other factors are controlled in order to produce butter of suitable flavor, body and texture, and composition.

Condition of Fat in Cream and Butter. The fat in cream constitutes a fat-in-serum emulsion. The condition of the individual fat globules in cream, which is much the same as it is in milk, is described in Chapter 2, page 12. Emulsions are of two kinds, temporary and permanent. A temporary emulsion can be made with a finely divided fat or oil in water. The more finely divided the droplets of oil, the longer the emulsion will exist. A crude example of a very incomplete emulsion and a rather exaggerated condition might be that of a ball of butterfat immersed in a pail of water. We should have fat in water, but the condition would be far from that which we describe as an emulsion. Obviously the butter would rise at once to the surface of the water. Now if we take the smallest droplet of fat or oil imaginable, immersed in water, it will take hours for it to rise to the surface. The rate of rise follows Stokes' law.

$$V = \frac{2}{9} G \cdot r^2 \frac{(d_1 - d_2)}{N}$$

V = Velocity or rate of rise in centimeters per second.
G = 981 dynes, or the force of gravity.
r = radius of globule.
d_1 and d_2 = the densities of the oil and the water (butterfat and serum).
N = the viscosity of the water in absolute units (serum).

The physics involved is too intricate for our purpose and is not considered further. It is given to show that the diameter or size of the oil droplet is one of the factors involved.

In milk we have a much more permanent emulsion than we have in oil and water, owing to the binding and colloidal properties of the proteins in milk. The rate of rise is definitely retarded, and complete separation does not take place as it would in water.

In cream we have largely the same constituents as in milk. The proportions of each, however, are greatly altered. We have a concentration of fat, and the percentage of total solids in average cream is about three times that of milk. Naturally, with much less free water, viscosity is greatly increased. Again, with reference to Stokes' law, it will be seen that the viscosity of the fluid in question is a factor in the rate of rise of fat. Cream, therefore, is a more permanent emulsion. It is not entirely permanent, however, as evidenced by the fact that the emulsion can be broken as in churning.

Butterfat in cream exists in the form of globules. These globules are grouped largely in clusters, although many may be isolated. Surface tension causes the globules to assume the form of spheres. The globules are surrounded by a protein layer which is thought by Titus, Sommer, and Hart [1] to be a layer of casein and by Wiese and Palmer [2] to be a protein similar to, but not identical with, casein. Establishment of facts is fraught with intricate technical difficulties.

The serum or buttermilk portion of cream constitutes the *continuous* phase and the fat the *discontinuous* phase. When cream is churned and butter is formed we have an inversion of phases. The butterfat is the continuous phase and the serum of butter is the discontinuous phase. Complete inversion is not accomplished until the butter is worked and the serum-water portion is divided into tiny droplets. Two tests to prove the inversion of phases are:

a. Paper-wetting method.

b. Use of water and fat-soluble dyes.

Paper-Wetting Method. Paper applied to the surface of butter becomes greasy or "wet" with fat. If water were the continuous phase, the paper would become wet with water.

Use of Dyes. Professor E. G. Hastings of Wisconsin University placed Sudan III in one pound print of butter and carbol fuchsin in another. The former is fat soluble; the latter is water soluble. After several weeks storage Sudan III had diffused quite extensively and the water-soluble dye was very restricted in its diffusion. This test indicates that butterfat is the continuous phase.

Churning Theories: *Foam Theory.* Dr. Otto Rahn explains the formation of butter theoretically. Tests of the foam formed on cream in churning show that the percentage of fat is higher in the foam than in the cream below. He states that foam formation is necessary. Under proper conditions of temperature the fat globules collecting in the foam stick to one another, forming larger and larger masses, until the serum is set free and we have the fat collected as aggregates or lumps of butter. Sommer [3] breaks down this theory, indicating that fat globules are not likely to be dragged into the foam. If partially whipped cream contains more fat, the greater amount of fat is more likely to be due to the tendency of both air cells and fat to rise and leave the denser cream below, with a lower percentage of fat. The constant agitation of churning would produce a rather homogeneous mixture, and fat and foam could not separate from the cream. Furthermore, limited experimental work indicates that churning may proceed faster in a partial vacuum, where little or no foam is formed.

Concussion Theory. Probably the most common conception of what takes place in the churn is that agitation of the cream causes the fat globules to strike one another, and, if the temperature is suitable, they adhere. As the agitation continues, larger and larger groups of fat globules are formed and the serum or buttermilk is gradually set free, the viscosity drops sharply at the "breaking" of the butter, and the size of the butter masses then increases very rapidly because of their greater freedom to strike and adhere.

Sommer again questions the concussion theory and indicates that there are many other factors involved besides mere striking and sticking of fat globules. Some of these are:

1. The abrasive effects as globules come in contact.
2. Viscosity.
3. Electric charge on the fat globules.
4. Variation of adsorbed film on fat globules.
5. Variation in salt balance.
6. Variation of cream acidity.

Abrasive effects. Fat globules in cream at churning temperature are largely clustered. Some globules may exist singly. The extent of clustering depends on several factors, mainly those listed above. These factors are, in turn, dependent upon the nature of the cream, the time and temperature of pasteurization, the original cream acidity and the extent of its reduction, the kind of neutralizers used and the manner of application, the time the cream is held before churning and the temperature at which it is held, etc.

When fat globules or clusters of globules come in contact by the agitation of churning, we may have an increase in the extent of clustering. As this grouping of the fat progresses, we finally arrive at a point of great viscosity. At this time the abrasive effect is increased. It is at this point that we have an inversion of phases and a subsequent free movement of butter particles in the serum or buttermilk. This possible abrasive effect is theoretical and may serve to help visualize what happens in churning, until facts are established.

Viscosity. The influence of viscosity of cream on churning may be made clearer by considering cream which is at the extremes of recommendable richness for churning. Cream testing 20 per cent fat has less viscosity than 40 per cent cream. From the standpoint of viscosity alone, it would churn more readily. Actually, it churns less readily owing to lack of proximity of fat globules and fat clusters. Rich cream (40 per cent) has greater proximity of butterfat units but its viscosity is too great at ordinary churning temperatures. Temperatures may be raised slightly to facilitate churning of rich cream, but this must not be recommended. It is far more desirable to standardize cream so that it will test between 28 and 33 per cent. It is exceedingly rare to have a vat of cream testing over 35 per cent, and fat standardization is not a problem in the local creamery. There is greater possibility of handling overrich cream in central creameries, where a large volume of direct-shipper cream is received. Producers shipping cream long distances skim richer cream to avoid excessive transportation costs.

Electric charge on fat globule. This subject is definitely in the experimental stage in so far as the practical creamery operator is concerned. Fat globules are negatively charged. The degree of charge or relative negativity depends upon a number of factors, two of which are the temperature of the cream and the number and nature of positive ions present. The charge is appreciably reduced when cream is cold. Since like electric charges repel, we find little or no clustering of fat globules at pasteurizing temperatures because their negative charge is increased. When pasteurized cream is cooled, clustering again takes place; lower temperatures facilitate this action.

The influence of ions on the negativity of fat globules is shown by North and Sommer.[4] They added chlorides of potassium, calcium, iron, and thorium. The last three caused decreases of the electric charge. Thorium at certain concentrations caused an actual reversal of charge. More rapid churning should result by the addition of such chemicals to cream. This is of theoretical interest only, because the addition of these substances undoubtedly is illegal. Reference is made to this work because the addition of neutralizers to cream may influence slightly its churnability.

Variation of adsorbed film on fat globules. The exact nature of the protein film surrounding fat globules has not been determined. It has been theorized that the nature and thickness of this film on fat globules in cream to be churned may not be constant owing to natural variations in milk composition and to the treatment of cream before churning. Our present knowledge does not enable us to make statements regarding its influence on churning phenomena.

Variation in salt balance. The mineral content of milk varies slightly from time to time. Such variations are difficult to determine by routine chemical analysis. Only slight changes are necessary, however, to affect the stability of milk and cream. Feathering of sweet cream and excessive heat coagulation of evaporated milk are examples of the influence of a slight abnormal excess of calcium and magnesium ions. The instability is remedied by the addition of monovalent sodium ions, such as are found in baking soda or sodium citrate.

In processing sour cream, we alter the salt balance by the addition of neutralizers. This may have some effect on churning. Its practical significance appears to be negligible.

Variations in cream acidity. This subject is discussed later in this chapter. (See page 211.)

We may assume, therefore, that the churning process is not so simple as it may at first appear. The student and plant operator are not so much concerned with the technological aspects. From the experimental standpoint, however, further understanding of the principles involved may result in some different or modified method of separation of the fat and serum.

Butter without Churning. Butter has been made with entire lack of agitation. The Keating Creamery at Yankton, South Dakota, has used a process in part similar to C. C. Processes, Inc. Cream is neutralized, diluted with water, and pasteurized by the flash, live-steam-injection method to 190° F. It passes immediately to the separator, which produces a cream with 80 per cent of fat. This cream flows continuously over a refrigerated drum, and the chilled fat is scraped off. This cream readily passes to butter with only a little working, and a small amount of serum separates. Salt is added during the working and a product results which in appearance and taste is like commercial butter. This is not a commercial process, and is explained briefly here only to show possibilities of producing butter in ways other than the common method of churning.

Composition of Butterfat. The following data are assembled mainly from Richmond [5] and Lewkowitsch.[6]

			Per cent of total	Approximate melting point. Degrees Fahrenheit
Butterfat	8 per cent volatile fat	Butyrin	3.85	− 66 or less
		Caproin	3 60	− 12
		Caprylin	0.55	+ 46
	92 per cent nonvolatile fats	Olein	35.0	+ 20
		Pa mitin	25.7	+145
		Myristin	20.2	+135
		Laurin	7.4	+112
		Caprin	1.9	+ 87
		Stearin	1.8	+150

Authorities differ in data on the melting points of the fats in butter. It is probable that melting points of fatty acids are more easily obtained and are in better agreement.

The fats in butterfat exist largely as triglycerides. We may have all three of the fatty acid radicals in palmitin as palmitic acid radicals. We may have each fatty acid radical different, as, for example, myristo-palmito-olein, etc. Since the feed and season influence the percentages of the various fats in butter and, as a result, the percentage of unsaturated and volatile fats varies, there may also be shifts in the various fatty acid radicals in a single fat. Single fats are not easily isolated. Some crystallize out in pairs very readily but may be difficult to separate. Methods of isolation may alter chemical structure, which may be the reason authorities differ in data regarding melting and solidifying points for the various fats of butter. Figures for the melting point of olein agree fairly well and range from — 4° to + 6° C. However, we find tripalmitin melts at 63° to 64° C. and solidifies at 45° to 47° C. Trimyristin melts at 45° to 55° C. and solidifies at 57° to 58° C. Obviously, with such variations in melting and solidifying points and with 8 or 10 different fats in combination, the exact physical condition of each or of the combination of fats in butterfat at any given temperature is uncertain.

Percentage of Olein Important. It will be noted that olein constitutes on the average one-third of the fats of butter. Attention is called to the very low melting point of olein. When cream is being churned, the olein is in liquid condition. The butter appears solidified. This is due to the mechanical holding of the olein by the other relatively hard fats, as palmitin and myristin. When cows are turned to pasture there is a remarkable increase in the olein content. It may go as high as 40 per cent, and the effect on the softness of butterfat is obvious. Churning temperatures must be dropped rather sharply and the time of holding cream prolonged. Holding the cream longer, however, is not so easily practiced at this season because of the increased volume and the necessity of turning out butter more rapidly.

Factors Affecting the Churnability of Cream. The factors affecting the churnability of cream are:

1. Temperature of churning.
2. Temperature of cream and time it is held before churning.
3. Composition of butterfat.
   a. Season and feed.
   b. Stage of lactation.
   c. Breed of cows.

4. Agitation—kind and extent. Churn.
   a. Make.
   b. Speed.
   c. Size.
   d. Load in churn—one-third to one-half full.
5. Richness of cream—30 to 34 per cent desirable.
6. Acidity of cream.

Temperature of Churning. The correct churning temperature for any particular plant or locality must be determined by the man who is doing the churning. The factors which affect the time required to churn and the completeness and exhaustiveness of churning are so numerous and complicated that experience alone must be the final guide. A general statement regarding the time of churning can be made. It should require from 40 to 60 minutes. At times during the year, and under particular conditions, a 40-minute period produces very good results. During the late fall and the winter season this is likely to be true. Butterfat is harder, and the body of the butter will be sufficiently firm. During the pasture season and in the early fall it may be necessary to churn at such temperatures that one hour is required for churning. More prompt churning might result in soft butter which would require considerable chilling with wash water. Wide fluctuations in wash-water temperature should be avoided. Longer churning periods in the fall of the year may be warranted because of small fat globules in the cream owing to cows nearing the end of the lactation period.

The two primary objects to keep in mind are:

1. To churn exhaustively, i. e., to leave as little fat in the buttermilk as possible.
2. To produce butter with a rather firm body, as firm as possible consistent with a reasonable amount of working to incorporate moisture thoroughly.

Churning temperatures usually range between 45 and 55° F. Under certain conditions a wider range may be indicated, such as 40 to 60° F.

Cold cream has a much greater viscosity and may not churn at all. Warm cream, 60 to 75° F., will churn in a very few minutes. The butter will be exceedingly soft and will not have the usual characteristics of good commercial butter, even after thorough chilling in the finished package. The losses of fat in the buttermilk will be exceedingly high. They may run as high as 5 to 8 per cent and, of course, such losses in a well-regulated creamery are unthinkable. The usual range of fat losses is from 0.4 to 0.7 per cent. The following graph (Fig. 54) will present the story of churning temperatures more quickly than further discussion.

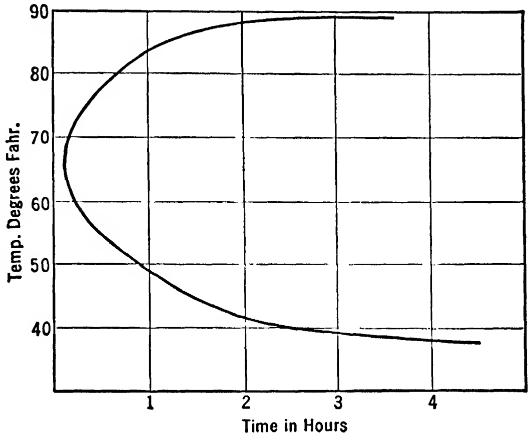

FIG. 54. Theoretical graph of time-temperature relationship in churning. At low temperatures, cream is too viscous and insufficient agitation occurs; hence little or no churning. As higher temperatures, and particularly as 93° F. (melting point of butterfat), are approached, churning ceases. The protein material covering the fat globules loses its ability to cause the globules to adhere and little or no massing of the fat takes place, and consequently no churning.

Temperature of Cream and Time of Holding It before Churning. Cream should be cooled promptly after pasteurizing and should be held below churning temperature if the holding period does not exceed 2 to 4 hours. If it is to be held overnight, it should be cooled considerably below churning temperature, for two reasons:

1. To allow for a gradual rise in temperature overnight due to
   a. Equalization of fat and serum temperatures.
   b. Residual heat in vat insulation.
   c. Room temperature.
2. To preserve the quality of cream which suffers considerably unless lower temperatures are maintained.

Without sufficiently low temperatures, the cream churns too rapidly and fat losses in the buttermilk are increased. Time is required for equalization of fat and serum temperatures, and fat solidification goes on over a period of hours. Vat insulation holds some heat which tends to raise cream temperatures. The theoretical graph given here (Fig. 55) will help to visualize the explanation.

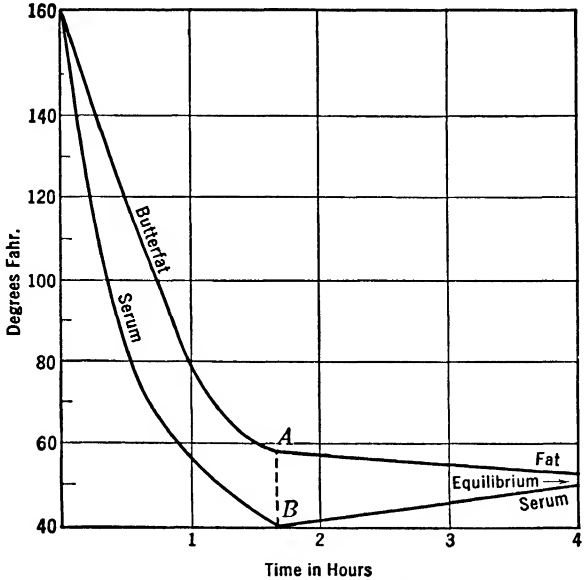

FIG. 55. Theoretical graph. Temperatures of fat and serum portions of cream during cooling and holding. Cooling stopped at line *A–B*. Temperature at *B* (40° F.) is recorded on the thermometer.

NOTE: Actual temperature differences are less. In addition to temperature equilibrium, fat crystallization is also an important factor in the rate of cooling, the temperature cooled to, and the time held before churning. See references to the work of Abbott; also Coulter and Combs.

It has often been observed that a two-hour holding period for cream at low temperature may require a 48° F. churning temperature, whereas cream held relatively cold over night may be churned at 53° F.

Composition of Butterfat: Season and feed. Butterfat varies considerably in composition during the year. When cows are turned to pasture the olein content of butterfat may increase 8 to 10 per cent or a total of about 40 per cent. The volatile fats also increase in percentage. Softer butterfat is the result, and churning temperatures must be consistently reduced if the churning time is to be sufficiently long to churn clean and produce firm-bodied butter. (The composition of butterfat is presented in detail on pp. 196-197.)

Recent studies of body and texture of butter indicate that conventional methods of handling cream prior to churning may be altered and that definite improvement is effected. Holding periods, churning temperatures, and wash-water temperatures can be changed at certain seasons with definite improvement in quality. Coulter and Combs [7] recommend two sets of conditions, one for summer butter and one for winter butter. Their work was undertaken because of the prevalent criticism of stickiness of winter butter. Very definite improvement was noted when cream was not cooled unnecessarily low. Churning temperatures were as high as were consistent with avoidance of undue fat losses in the buttermilk. Wash-water temperatures 10° to 15° F. below churning temperatures were used. The butter was allowed to remain in this water 10 minutes, or in some instances the churn was revolved to facilitate more even and complete chilling of the fat. The butter required more working to get sufficient moisture, but it withstood the working far better and the texture of the butter was greatly improved.

Briefly, their recommendations are:

(For winter butter)

1. 40° F. wash water.
2. Avoid excessive cooling of cream.
3. Avoid rapid cooling over surface coolers.
4. Churning temperatures not lower than needed to secure exhaustive churning under normal conditions.

(For summer butter)

1. Summer butter is normally soft—relatively high wash-water temperature, about 50° F.
2. Cool cream to low temperatures and hold cold.
3. Churn at as low temperatures as possible.

NOTE: It must be understood that these recommendations apply to conditions comparable to those in Minnesota.

Keith, Rink, and Kuhlman [8] at the Oklahoma station studied the control of body of butter made from cream produced by cows fed cottonseed meal. Cottonseed-meal butter was compared with that made from normal cream (no cottonseed fed) and was found to be gummy unless remedial conditions were practiced. When cottonseed-meal cream was pasteurized, cooled, and churned with less than one hour of holding, the body of the butter was satisfactory. If held two hours, the body was gummy, and, if held four hours, the body had a pronounced gumminess.

Richardson and Abbott [9] of California studied sticky body in butter with particular reference to the influence of alfalfa on the composition of butterfat. They were able to produce very definite improvement both experimentally and commercially by the following procedure:

1. Pasteurize at 145° F. — 30 minutes.
2. Cool to 110° F. with water
3. Cool rapidly from 110° or 100° F. with brine to a temperature which will cause churning in 50 to 60 minutes (usually 8° to 10° F. below normal).
4. Churn immediately.
5. Wash butter with water 3° to 4° F., below the temperature of buttermilk. If butter appears soft, use water 10° F. below buttermilk temperature.
6. Churning, washing, and working should be completed without delay. Delay causes excessive crystallization of fat.

Wilster and Stout [10] have studied the firmness of Oregon butter and found significant differences within a single state. Three general regions were defined, and noticeable differences in both fat and butter characteristics were observed. See Table opposite.

Such criticisms as "brittle, crumbly, sticky" are frequently made of butter from the Eastern and Southern section, where large quantities of alfalfa hay are fed.

The foregoing discussion of results of several investigators in widely separated sections of the country indicates some similarity of problems involved in producing butter free from sticky, crumbly, or gummy body. The basic consideration involved appears to be the relative amounts of liquid and crystalline butterfat at the time of working the butter. Coulter and Combs make a further suggestion relative to the formation of smaller crystals by rapidly cooling the

TESTS ON OREGON BUTTER

	Melting point	Depression grams—11° C.	Extrusion or spreading ability—11° C.
Coast	32 8 C.	0.58	28
Valleys	33.4 C.	0.78	39
Eastern and Southern Oregon	33.9 C.	0.89	50

(Data for February)

Coastal region—long pasture season; root crops. Valleys—short pasture season; variety of crops. Eastern and Southern Oregon—major feed, alfalfa hay.

Melting point—method of A. O. A. C.

Depression or penetration—according to Perkins, *J. I. E. Chem.*, Vol. 6, No. 2, 1914. (Weight to displace 1 cubic millimeter of butter.)

Extrusion—method of J. D. Sargent, *N. Z. J. Sci. and Tech.*, Vol. 16, No. 4, 1935. (Pounds air pressure required to force butter from tube through standard aperture.)

cream. They suggest that larger portions of liquid fat as produced by slower cooling and larger crystals help prevent the tendency to stickiness as observed in drawing a trier from butter.

It appears that the buttermaker must survey feeding conditions properly and change methods of processing from time to time if he is to avoid body and texture defects. Since the flavor of butter is of equal or greater importance than body, any methods followed must be consistent with preservation of the most desirable flavor.

The influence of feeds which cause marked changes in the physical and chemical characteristics of milk fat has been studied. There is such a variety of feeds used in the various sections of the country that the problem of determining their influence is exceedingly extensive. If little effect is apparent, there is no great need of investigation, if the flavor of the milk and milk fat are suitable.

Green feeds (pasture) in general produce softer fats by increasing the percentages of olein and volatile fatty acids. Most dry feeds produce harder fat by increasing the percentages of the high-melting-point fats, such as myristin, palmitin, and stearin. Examples of dry feeds which do not do this are soybean meal and soybean hay. Soybean meal produces softer milk fat and softer body fats in animals. Cottonseed meal produces hard fat but does not do so by reducing the olein content. It probably decreases the percentage of volatile fatty acids.

Hunziker, Mills, and Spitzer [11] indicate that germ oil, corn oil, linseed oil, linseed meal rich in fat, cottonseed oil, soybean oil, gluten feeds rich in fat, and bluegrass pasture raise the olein content of milk fat. They also state that feeds that tend to produce milk fat with less olein are potatoes, corn meal, corn silage, sweet-corn fodder wheat bran, sugar beets, etc. These feeds are rich in starches and sugars and low in vegetable oils.

Stage of lactation. Fat globules in milk are smaller toward the end of the lactation period. Hunziker, Mills, and Spitzer [11] show that, in six breeds, the fat globules were about one-half as large at the tenth month of lactation as they were the first month.

It has been stated and assumed that milk fat is harder toward the end of the lactation period. This is uncertain. Hunziker, Mills, and Spitzer [11] present data indicating that butterfat is actually softer as the lactation period progresses. The change in the melting point of butterfat due to stage of lactation is slight. The feed of cows is far more important. Difficulty in churning most frequently occurs during the fall and winter months. This trouble is due frequently to small fat globules and to the fact that butterfat is harder. It is harder because of a change of feed rather than because of the stage of lactation.

There is a possibility that the adsorbed protein on the surface of fat globules is changed slightly as the lactation progresses. The protein content of milk is greater toward the end of the lactation period. The percentage of ash also increases. We may logically assume that the salt balance of milk is slightly out of adjustment and that the adsorbed protein layer on the fat globules may be altered. This, in turn, may reduce the tendency of fat clusters to adhere during the churning process.

Krukovsky and Sharp,[12] at Cornell, studied the churnability of cream from milk of cows in advanced lactation, summarizing as follows:

1. The difficulty in churning and the abnormal foam formation found in cream obtained from the milk of cows in advanced lactation is probably due largely to lipolitic action and the concentration of the resultant soaps and fatty acids in the air-plasma interface.

2. Less difficulty in churning and less lipolytic action are encountered if the cream is separated while the fat globules are in a liquid state as contrasted to the solid state.
3. Pasteurizing milk or cream as soon as drawn largely prevents the difficulty in churning.

Churning temperatures can be raised when churning is delayed. If it is a fact that the cream is coming from a large percentage of "stripper" cows, it is unwise to raise the churning temperature too sharply. Rapid churning when many small fat globules are present in cream causes increased buttermilk fat losses.

Breed of cows. The so-called Channel Island breeds, the Jersey and Guernsey cows, produce butterfat which is somewhat harder. The fat globules in the milk of these breeds are definitely larger. The first consideration would tend to cause longer churning periods and the second would tend to reduce the churning period. The two factors tend to offset each other but not entirely. It has been frequently observed that churning temperatures are somewhat lower where Jersey and Guernsey cows predominate.

Agitation and Churning: Kinds of churns. Churns of different design have some effect upon the nature and degree of agitation. The old rectangular box churns were less efficient than the standard combined churns and workers. It is unlikely that there is any great difference in churning efficiency in the standard shelf- and roller-type churns of the same diameter, even though their internal construction differs.

There are, however, three churns of quite recent design on the market. The Jensen all-metal aluminum-alloy churn is a hollow boxlike structure with bearings at corners. The Crano spiral churn has an outside appearance like standard factory churns. It has two sloping shelves from end to end of the churn, but has no rollers or moving parts in the churn. The Vane churn is also of standard outside appearance. Instead of shelves, it has four triangular-shaped vanes, two at each end of the churn. These are set at an angle and cause the cream to move back and forth from end to end of the churn. These rollerless churns have no moving parts inside. No data are available to show that the churning efficiency of these churns is different from that of the churns now used in most creameries. (See Figs. 70, 69, and 71.)

Two additional no-roll churns were introduced late in 1938 by the Cherry-Burrell Corporation (See Fig. 72) and by the Creamery Package Manufacturing Company (See Fig. 73). The manner of working in each differs. All no-roll churns, however, utilize the weight of the mass of butter in the working process, whereas the roll churns use a pressing movement.

The amount of agitation or the movement of the cream must be such that the fat particles and clusters come in contact with sufficient force to produce progressive gathering into larger and larger units. Insufficient movement or lack of force in striking of these units will cause delayed churning. Too much force will tend to break apart some of the units already formed. When a churn is about one-half full (maximum load), the lifting devices, shelves, rollers, etc., tend to be submerged during the greater part of the complete turn of the churn. This decreases the agitation of the cream by reducing the distance it falls before striking the mass of cream below. When a churn is about one-third full, the effects of striking and agitation are increased, and churning is completed in less time. It is common practice to lower the churning temperature slightly when the churn is one-fourth to one-third full.

Speed of churns. Churns are geared to produce maximum agitation and still maintain reasonable mechanical balance and power requirements. It is possible to secure greater agitation than is produced in some churns. The extra power requirements for higher speed and the shortening of the life of the churn, however, forbid such construction. The following churn speeds are recommended by a prominent churn manufacturer:

Churn Diameter	Speed
55.5 inches	23 r.p.m.
54.5 "	25 "
28.0 "	31 "

On another small churn of 20.5-inch diameter, a speed of 30 r.p.m. is set. In this case, no doubt, the length of the barrel is a factor. Likewise on three factory-size churns of different capacities, but having the same diameter of 45⅜-inches, the speeds recommended vary from 23 to 28 r.p.m. They state that the difference is due to belt-drive construction and possible belt slippage. Modern motor-driven churns largely eliminate such speed variations and promote more uniform churning conditions.

It may facilitate understanding if imaginary conditions are given. Suppose a churn rotated 1 r.p.m. The cream would remain in the bottom of the churn and get almost no agitation and consequently little, if any, churning would take place. On the other hand, if we imagine a churn rotating at 500 r.p.m., the cream would be thrown by centrifugal force against the inside periphery of the barrel and remain more or less stationary, with no agitation and no churning. The speed of churns is established by actual churning tests and is set to produce results under average churning conditions.

Size of churns. In general, the larger the churn diameter, the shorter the churning time with proportional loads of the same cream. Larger churns raise the cream to higher levels, as the churn rotates and the cream moves and splashes more vigorously. Greater agitation and shorter churning periods result. Since short churning periods are undesirable as previously explained, the rational procedure is to churn at lower temperatures and continue churning for a normal period of about 45 minutes. The diagram given here (Fig. 56) demonstrates the principle.

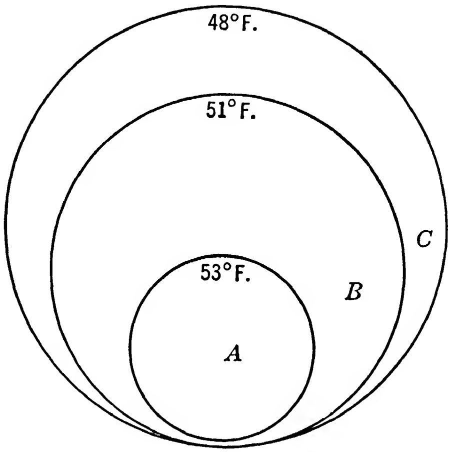

FIG. 56. Theoretical relationship of size of churn to churning temperature, to complete churning in same time.

Churn	Diameter inches	Probable churning temperature degrees F.
A	28	53
B	48	51
C	60	48

Load in the churn. A normal load for a churn is one-third to one-half full. Overloading a churn is likely to cause delayed churning, and all too frequently the buttermaker will use higher churning temperatures in order to churn in normal time. (See Fig. 63.) This results in greater loss of fat in the buttermilk and may interfere with moisture control, particularly in the summer season. Unduly small loads may also prolong churnings because of insufficient agitation. The cream may merely cling to the churn surface and especially so as it whips and becomes more viscous. Overloading or underloading churns is likely to result in loss of time due to churning difficulties and requires more effort to control properly the composition of butter. Good judgment indicates a normal and uniform load if uniform butter is to be made. Body and composition of the

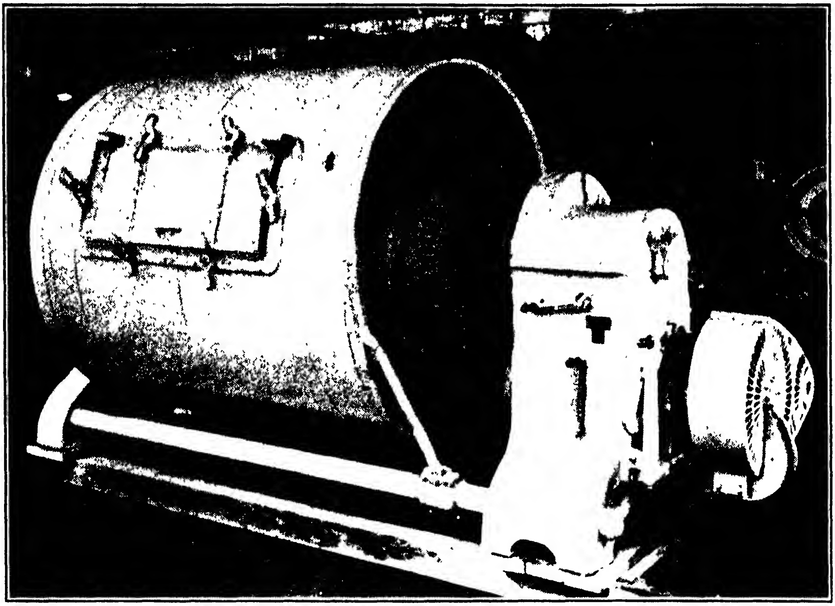

Fig. 57. New Model "H" Churn, formerly called the Victor; a 2-roll churn. Courtesy Creamery Package Manufacturing Co.

butter and buttermilk fat losses are all at stake. Low overruns are frequently obtained with small churnings and often are due to low moisture in the finished butter. If a churn is more than half full the cream frequently whips to such an extent as to so fill the churn that agitation practically ceases. If this is suspected, the operator must stop the churn with the door well near the top to avoid loss of cream when the door is opened for observation.

If the cream is extensively whipped it may be necessary to draw a portion of it from the churn. Add some water or skim milk to the cream in the churn, being careful to avoid excessive dilution.

The water or skim milk added to the churn may be warmer than the cream. This produces a double effect. The cream is diluted, thus reducing its viscosity, and the churning temperature is raised slightly. Judgment must be used in raising the temperature in order that soft butter may be avoided.

If the churn is not too full and if whipping is not excessive, warm water may be sprayed on the outside of the churn as it revolves. The barrel of the churn is warmed, the cream may break away from the walls, and churning may be completed without undue delay.

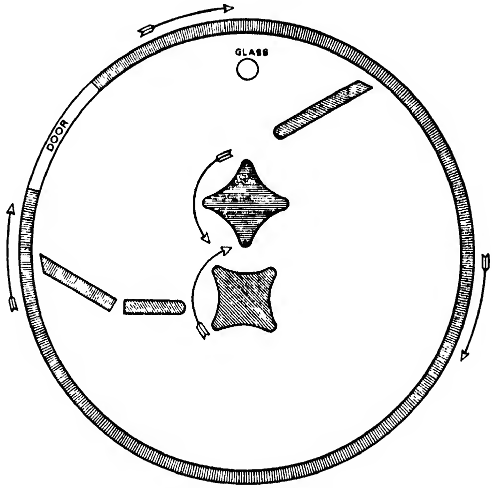

FIG. 58. Cross-section of the Model "H" Churn. Courtesy Creamery Package Manufacturing Co.

Another possible way of correcting excessive whipping of cream is dashing a few pounds of salt over the cream. This increases the surface tension, tends to cause the foam to collapse, and may facilitate churning. In addition, the salt has a "salting out"

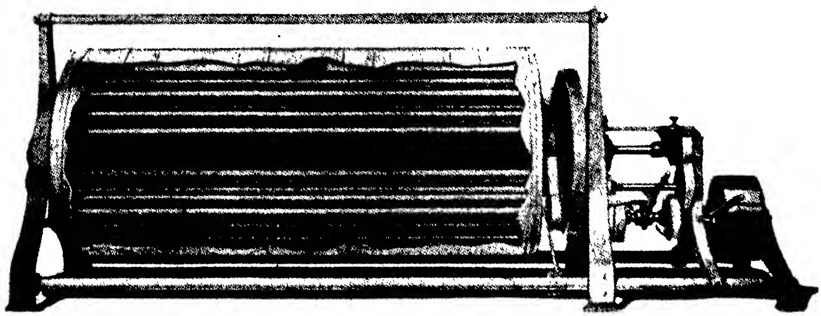

FIG. 59. Victor 4-roll churn, cut-away view showing position of workers. Courtesy Creamery Package Manufacturing Co.

effect on proteins in the cream. Partial agglutination of protein may occur and, with a freer movement of water, churning is completed more promptly.

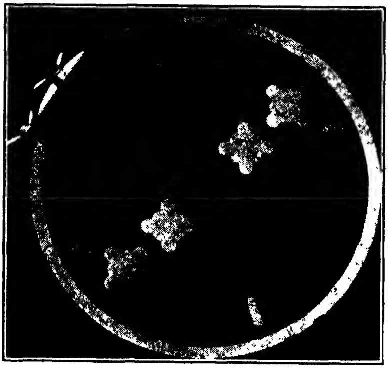

FIG. 60. Cross-section of C. P. Victor No. 10 churn. When four or more rolls are used, the shelf size is much reduced. Courtesy Creamery Package Manufacturing Co.

Richness of Cream. The test of cream desired for churning is 30 to 35 per cent butterfat. Thinner cream requires more time to churn, and richer cream usually becomes so excessively viscous that churning is delayed. The fat globules in thinner cream do not strike so frequently, which explains the longer churning period. In rich cream, the viscosity interferes with the striking of the fat globules. They move sluggishly, and contact is infrequent. Whipping may occur and churning may be greatly delayed. (See Figs. 64 and 65.)

FIG. 61. Danish combined churn and worker; modern, 6-roll churn. Note large diameter, short-barrel construction. Comparable to recent American trends in churn construction. Courtesy Paasch, Larsen, and Petersen; Horsens, Denmark.

Acidity of Cream. Sour cream churns more readily than sweet cream. The natural colloidal condition of sweet cream offers greater

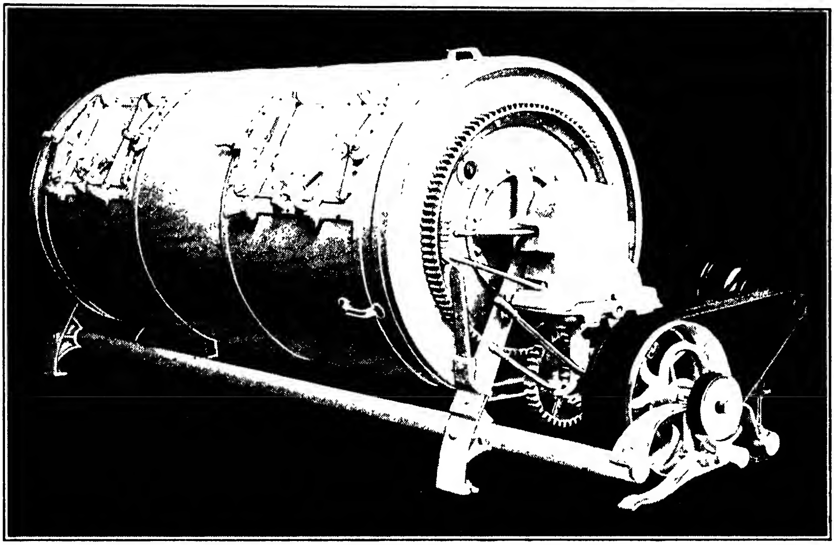

Fig. 62. Single-roll churn. Long-barrel, small diameter type now being replaced by the short-barrel, large diameter churns. Built as a belt-driven machine; partly modernized by installation of a separate motor. Courtesy Cherry-Burrell Corporation.

resistance to the striking of fat globules and, consequently, more time is required to complete churning. Development of appreci-

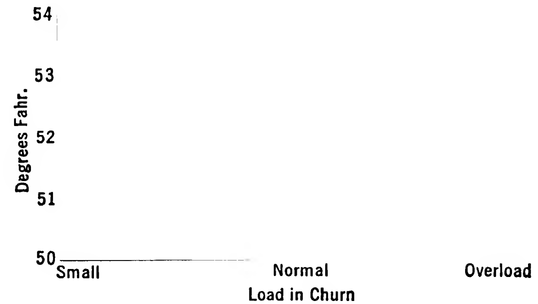

Fig. 63. Theoretical representation. Churning temperatures for variable churn loads.

able amounts of acidity tends to destabilize the casein. Agglutination of casein particles occurs, and the water of the cream serum moves more freely. This permits more frequent fat-globule collisions, and therefore churning proceeds more rapidly. Slightly soured cream is more viscous than sweet cream and may require a slight

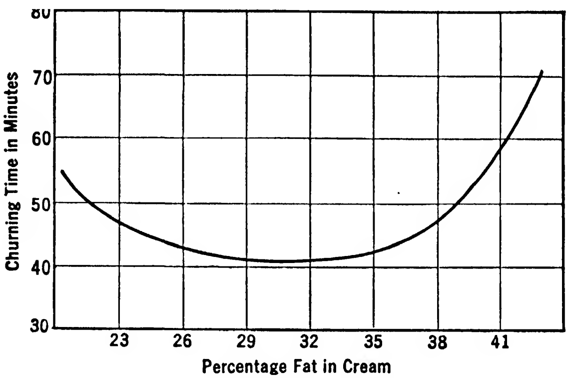

FIG. 64. Theoretical representation. Churning time required for cream with various fat tests.

increase in churning temperature to avoid whipping or prolonged churning. When cream reaches a serum acidity in excess of 0.6 per cent, casein is coagulated and churning is facilitated.

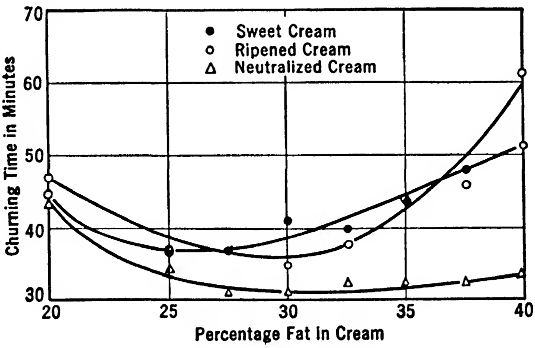

FIG. 65. The relationship between the percentage fat in the cream and the churning time of the cream. From Iowa Research Bulletin 214, 1937, by Bird and Derby.[13]

Note the general fact that cream testing betwen 28 and 32 per cent fat churns in less time. Rich or thin creams require more time. Important differences are shown in creams testing 35 to 40 per cent. It will be noticed that less variation is found in neutralized cream. This points to the advisability of churning cream with 30 per cent or more of fat, both from the standpoint of time to churn and from percentage of total fat lost in the buttermilk, as shown by data in the same bulletin.

The sourness of cream as a factor in churning is relatively unimportant in creamery work except when unsalted butter is made. Cream for unsalted butter is frequently ripened to 0.40 to 0.45 per cent acidity. If such cream tests 30 per cent butterfat, its serum acidity is 0.60 per cent, or more. It has therefore reached an acidity which causes some coagulation of casein, and churning is facilitated.

In the manufacture of salted butter, cream acidities usually do not exceed 0.3 per cent. The viscosity of such cream is not appreciably greater than sweet cream. The time and temperature of holding the cream before churning have a greater effect on viscosity than the acidity.

Sour cream churns more exhaustively (i.e., with less loss of fat in the buttermilk) than sweet cream churned for the same length of time. To cause sweet cream to churn with less loss of fat in the buttermilk, it must be churned at slightly lower temperatures.

Buttermilk Fat Losses. Buttermilk fat losses usually range from 0.4 to 0.7 per cent and average about 0.5 per cent. The causes of fat losses have already been discussed in considering the factors affecting cream churnability. (See pp. 197-212.) A list is repeated here to aid in review.

Factors causing increased fat losses in buttermilk:

1. Too high churning temperature and quick churning.
2. Sweet cream unless churned at lower temperatures.
3. Churning rich cream because of the tendency to raise churning temperatures.
4. Too much or too little cream in the churn—because of tendency to raise churning temperatures.
5. Stripper cow cream and smaller fat globules.
6. Holding cream too short a time before churning.
7. Churning raw cream which has been frozen.
8. Failure to reduce acidity to 0.25 per cent, or lower, before pasteurizing.
9. Reduced churn speeds with consequent reduced agitation (belt slippage).
10. Stopping churn too soon; tiny butter lumps pass through screen.

Results of experimental work at the Minnesota State Creamery at Albert Lea, Minn., in 1932, reported by Combs,[14] show that the fat losses can be greatly reduced by proper care. In some instances it required two or three hours or more for churning. An average of 60 minutes is suggested for improved results.

Unusually Low Buttermilk Fat Losses
(Fat analysis by Babcock method)

Year	Number of Churnings	Average Per Cent Fat in Buttermilk
1926	513	0.208
1927	477	0.180
1928	532	0.108
1929	593	0.082
1930	594	0 087
1931	510	0.071

The tests reported in this work appear to be appreciably lower than average creamery results. They are presented to show possibilities. Obviously, no creameryman will churn at temperatures so low that two or three hours are required to churn. The extra cost of labor and power would be greater than the extra savings in fat. Churning conditions must fit into a balanced program where all costs and the quality of butter must be considered. The work of Coulter and Combs [7] is one illustration that body and texture of butter may suffer if extreme conditions are resorted to in order to gain efficiency in exhausting churning.

Combs [15] previously (1925-1926) had showed average fat losses in 386 samples of buttermilk from Minnesota creameries. Average losses were as follows:

Fall	Winter	Spring	Summer
0.5619 per cent	0.5570 per cent	0.7901 per cent	0.6922 per cent

Bird and Derby [13] of the Iowa station studied fat losses in buttermilk. Using the Majonnier test for fat, they found losses as follows:

Relation of Richness of Cream and Season to Buttermilk Fat Losses

Fat test of cream	20	25	27.5	30	32.5	35	37.5	40
Jan. 15 to Mar. 13 Av. 11 churnings	0.626	0.605	0.613	0.646	0.715	0.754	0.807	0.921
Mar. 20 to Apr. 10 Av. 7 churnings	0.700	0.667	0.680	0.752	0.772	0.829	0.942	1.069
Apr. 15 to May 6 Av. 6 churnings	0 681	0.632	0.642	0.671	0.740	0.829	0.870	1.004

TESTING METHODS—RICHNESS OF CREAM AND BUTTERMILK FAT LOSSES

Fat test of cream	20	25	27.5	30	32.5	35	37.5	40
Majonnier..% Fat in B Mk.	0.626	0.611	0.613	0.646	0.715	0.754	0.807	0.921
Am. Ass'n... "	0.557	0.542	0.544	0.577	0.648	0.688	0.742	0.859
Minnesota.. "	0.413	0.397	0.399	0.435	0.509	0.551	0.608	0.731
Babcock.... "	0.170	0.160	0.162	0.183	0.229	0.255	0.290	0.365

Am. Ass'n —American Association test (butyl alcohol.)
B. Mk.—Buttermilk.
Tests 2, 3, and 4 were computed using formula given in Iowa Research Bull. 175, "Chemistry of Butter and Butter Making," Part 2, 1935.

This comparison of methods of testing buttermilk shows considerable variation in results both in the table and as illustrated in Fig. 67. The Babcock method is conceded to be inaccurate. The tiny fat globules in buttermilk are difficult to separate by ordinary

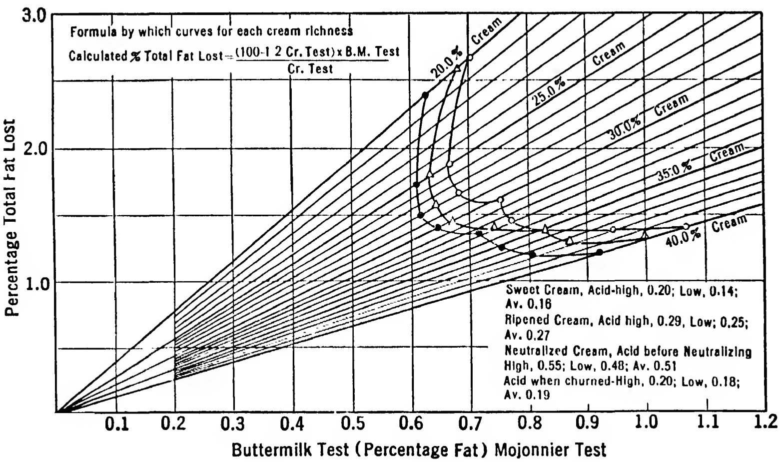

FIG. 66. The relationship between the percentage total fat lost and the fat test of the cream. From Iowa Research Bulletin 214, 1937, by Bird and Derby.[13]

. —Sweet cream, average 0.16 per cent acidity.

○—Ripened cream, average 0.27 per cent acidity.

△—Neutralized cream, average 0.19 per cent acidity.

Note that the fat test of the buttermilk varies but little with cream testing between 20 and 28 per cent fat. When cream with 30 per cent fat or more is churned, fat tests of buttermilk increase quite sharply. The buttermaker usually pays too much attention to buttermilk tests as an index to efficiency, whereas the percentage of total fat lost is a prime economic factor. The authors point out the inadvisability of churning cream with less than 30 per cent butterfat.

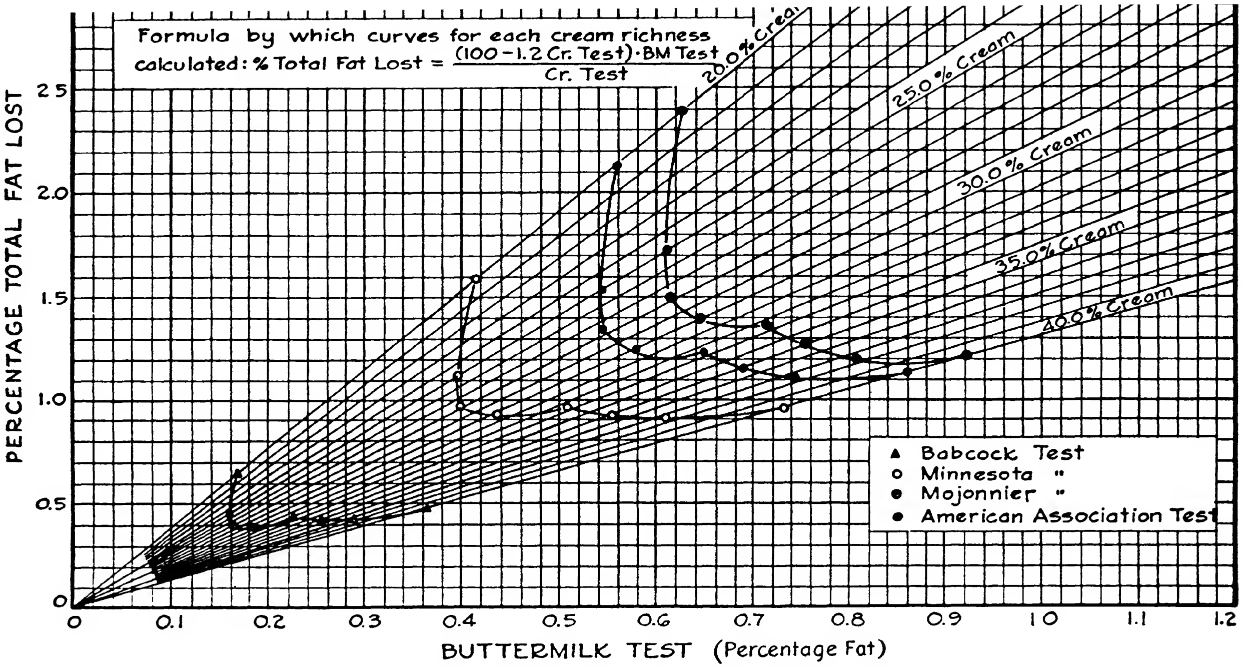

FIG. 67.—The relationships among the cream test, the buttermilk tests by several analytical methods, and the percentage total fat lost in the buttermilk. From Iowa Research Bulletin 214, 1937, by Bird and Derby.[13]

This graph indicates differences in buttermilk tests made by four different methods. It also is intended to be used as a guide in checking butterfat losses in buttermilk. The data for the graph represent conditions between October and May. Conditions of churning were: 30 per cent cream, 4-hour holding period, held below churning temperature; churning temperature adjusted to cause 45-minute churning period, churn one-third full; both large and small churns, sweet cream, ripened cream, neutralized cream with 0.20 per cent churn acidity. The authors suggest the use of either the Minnesota test (original) or the American Association (butyl alcohol) test.

methods of centrifuging. The authors of Iowa Research Bulletin 175 suggest the use of either the American Association test (butyl alcohol) or the Minnesota test. In addition to pure butterfat, lecithin, cephalin, and cholesterol are separated with the true fat when using these tests. In churning, these fatlike substances are largely lost with the buttermilk and are neither desired nor recovered with the butter in appreciable amount. The important consideration is to test the buttermilk from each churning or, at least, sufficiently often to provide a reliable check on churning efficiency. If comparative results of the various tests are understood by the operator, he may choose any practical method and make every consistent effort to keep losses low. Factors which influence buttermilk fat losses are discussed later.

To indicate further the importance of fat losses, let us consider some figures.

ECONOMIC IMPORTANCE OF BUTTERMILK FAT LOSSES

Pounds of Cream	Pounds of Butter-milk	Av. Test	Possible Saving	Fat Savable Pounds	Value at 30¢ lb.	Value of Butter Lost
2,500, 1 churning....	1,500	0.60%	0.30%	4.5	$ 1.35	$ 1.68
25,000, 10 churnings..	15,000	0.60%	0.30%	45.0	$13.50	$16.87
50,000, 20 churnings..	30,000	0.60%	0.30%	90.0	$27.00	$33.74

These figures indicate that the operator who saves but 0.3 per cent of the fat lost in the buttermilk has a 0.201 cent price advantage in buying butterfat. It is one of a number of savings possible in creameries.

2500 lb. cream − (830 lb. fat ÷ 0.85) = 1524 lb. buttermilk
Suppose 24 lb. waste.

$1550 \times 0.0030 = 4.5$ lb. fat
4.5 lb. fat $\times 1.24 = 5.58$ lb. butter
5.58×30 cents $= \$1.674$
$1.674 \div 830 = 0.201$ cents

NOTE: Unfinished butter will have about 14 per cent water and 1 per cent curd; 100−15 = 85; 830 ÷ 0.85 = 976 lbs. unfinished butter; 2500−976 = 1524.

Straining and Filtering Cream. Since 1933, when the federal government started renewed activities in the inspection and condemnation of cream and butter, there has been much attention given to the cleanliness of these products. A very large percentage of butter enters interstate commerce, giving the federal authorities power to inspect and pass judgment on the purity and wholesomeness of these products. They spend considerable time in the inspection of cream delivered to creameries and intended for butter manufacture. Their efforts are based on the fact that cream must be pure and wholesome before processing into butter. Nevertheless, many creameries have not only made unusual efforts to secure good cream but have also installed cream filters to remove any sediment in the cream which may have passed unnoticed. One large creamery company outlines a procedure as follows:

1. Coarse strainer at dump vat.
2. 1/32 to 1/64-inch mesh strainers after forewarming.
3. Fine cloth at pasteurizers.
4. 1/32-inch mesh after cooler.
5. 1/16-inch mesh into churn.

Experience in many creameries has proved the advisability of filtering hot cream through an approved filter cloth. Only properly neutralized hot cream will pass without excessive force. The use of lime neutralizers must be rather restricted if there is difficulty in filtering. Gravity filtering is preferable but may not be practicable under certain conditions. The creameryman is now advised to strain milk for starter most thoroughly. He must carefully guard against contamination of salt. Butter wash water must be filtered through cloth. Washing powders and butter-handling equipment must be clean and protected. Churns must have screens over the doors when not in use. In short, vigilance is the watchword in every plant operation.

Preparing the Churn for Use. In preparing a new churn, use cold water for soaking. Drain and refill at intervals to help carry away wood odors. Cold water will swell the wood more gradually and a more even expansion will take place. Follow with hot water treatments. Use milk of lime with lukewarm water. If wood odors persist, use chlorine solutions. In no case should the operator use milk or buttermilk to absorb wood flavors and odors. The constituents of the milk will get into cracks in the churn and will remain a source of trouble for the life of the churn. It is much better to install and prepare churns for use during the season of low volume in order to allow plenty of time to prepare a new churn properly. Be extremely careful about loosening the metal bands on the churn. It is better not to loosen them at all than to loosen them too much and leave cracks for cream to lodge in. Instances are known where the bands were not loosened.

Churns that have stood idle for some time should be cleaned as carefully as possible. It may be advisable to remove the rollers and shelves. Scrape and brush all parts, including the interior of the barrel. Replace all roller bearings and pinions which are worn. Then proceed to prepare as directed for new churns.

Butter Colors and Their Use. There are two sources of butter-coloring materials, viz., vegetable and mineral or coal tar derivatives. Vegetable coloring is obtained from the annatto seed which grows on tropical plants in Central and South America and the East Indies. The coloring material is soluble in oil and various vegetable oils are used as vehicles for carrying the color. The oils used should be only the best grade neutral oils. Butter colors made in this manner retain their suitability for use for several months. However, most vegetable oils will ultimately break down somewhat, and attempts to overstock at low prices should be avoided.

Coal-tar colors used in making butter colors are those approved by the United States Department of Agriculture. They are non-poisonous. Formerly there were but few accepted coal-tar colors, and their use was delayed. Many states prohibited their use until quite recently. They are considered satisfactory for coloring butter, and in some instances are more concentrated than vegetable colors.

Purpose of Coloring Butter. Butter produced during the season of fresh green grass has the greatest intensity of yellow color. This is often referred to as June color. All coloring of cream and butter is done to match this natural June butter color. Obviously, the amount of artificial color used must be changed at various seasons. The amount used varies from none at all to about 3 ounces per hundredweight of fat. The maximum and minimum amounts depend upon several factors, chief of which are feed and breed of cows. The operator's judgment in maintaining a uniform color at all seasons is very important from the standpoint of marketability of the butter.

Color should be added carefully, avoiding the shelves and rollers. It should be added just before starting the churn. If color is forgotten, it may be added to the salt and thoroughly mixed. The colored salt should be well worked with the butter to be sure of final uniformity. The chief objection to this recourse is the fact that the body of butter may be affected by overworking. This is particularly true during the grass season, when butterfat is quite soft.

Butter color may be added to cream in the vats before transfer to the churn. This may seem advisable when two or more churnings are held in a single vat. In vat pasteurization, the color is best added after the holding period while the cream is still hot and in fluid condition. If color is added to cold cream in the vat, the operator must be very careful to see that the color is thoroughly mixed with cream. The appearance of portions of color floating on the cream indicates faulty mixing. This must be avoided.

In the long-barrel churns, particularly, the color should be distributed evenly from end to end of the churn. If more color is added at any one place in the churn, there is a possibility that butter at this point may have a deeper yellow color. In any type of churn it is wise to distribute the color evenly.

When to Stop Churning. Churning should be carried to the point when the butter granules are about the size of the corn kernels. There should be very few granules small enough to pass through the screen. This is judged by looking for these small granules on the churn door when lifted or on the ends of the churn. On the contrary, churning should not be carried to the point where the granules collect into lumps an inch or more in diameter. If churning temperatures are sufficiently low, the churning can be carried to the proper point without much danger of overchurning. Longer churning periods help to prevent overchurning. The churn man must watch carefully when the butter comes and avoid overchurning.

Overchurning of low-grade cream in particular is very undesirable. More of the fermented curd remains in the butter and it is very difficult if not impossible to remove any appreciable amount by washing. Increased amounts of curd in any butter are undesirable. The curd furnishes food for bacteria and keeping quality is lowered. It is common knowledge that butter oil keeps much better than butter.

If overchurning occurs, it is good practice to wash the butter twice. During the second washing the workers may be engaged and the butter should be worked some in the wash water to help wash out curd. The operator's experience is the best guide to the extent of such working. During the grass season, care must be taken to avoid excessive moisture. The wash-water temperature may be lowered to help avoid excessive incorporation of moisture.

Excessively low wash-water temperatures, however, are to be avoided. It is possible actually to increase the moisture content of butter by the use of very cold water. It is better to use water not more than 10° F. lower than the temperature of the butter, and usually 4° to 6° F. will suffice. (For sticky butter, see pages 201-203, Coulter and Combs.)

Good churning indicates that all churnings should be stopped at a point which will insure good washing. In the case of good or especially fine butter, one washing is enough. Excessive washing tends to wash out flavor and leave the butter flat or lacking in flavor. If second-grade cream is being churned, it may be advisable to wash the butter two or more times to help remove some undesirable flavors.

Delayed Churning. Sometimes churning is unduly prolonged. The operator may handle the cream in a satisfactory routine manner and is puzzled to find an explanation. Usually the trouble is promptly diagnosed by the experienced operator and an application of the principles affecting the rate of churning will overcome the difficulty. The most common causes of delayed churning are listed below. An attempt has been made to list in the order of importance.

1. Churn too full.
2. Churning temperature too low.
3. Cream too rich or too thin.
4. Abnormal cream due to the milk or age of the cream.
5. Homogenized or re-emulsified cream.

It is quite impossible in the ordinary creamery to know if cream has been homogenized. If such cream has been purchased from an ice-cream manufacturer, it may be suspected that it has been homogenized, and attempts should be made to verify the facts. Homogenized cream will not churn. If the churn is too full and the cream has whipped to such an extent as nearly to fill the churn, remove some of the cream and proceed. If the condition is not remedied, add a little water at about 100° F. Do not add too much water, as excessive thinning of the cream may result. If the delayed churning appears not to be serious, the addition of 5 to 8 pounds of butter salt may be effective in breaking the foam and the emulsion. Salt produces a curdling effect on the casein and it increases surface tension in the cream, causing the foam to collapse.

Washing and Care of Churn. In Chapter 18, "Sanitation," considerable space is devoted to the churn as a source of contamination of butter. The washing and care of the churn therefore deserve the constant attention of the efficient operator. The churn must be properly washed and chilled before each day's run. This is possible only when the churn is thoroughly cleaned and disinfected after each day's work. All traces of fat must be removed. When fat remains on the surface of the wood or is embedded in the wood, water will not wet it. This provides a surface to which the fat in the butter will adhere. The result is what is known as a "sticky churn." Even very soft butter will adhere but little to wood which is thoroughly wet. Fat has affinity for fat but none for water. The ends of the churn usually give most trouble. The butter scrapes against them during the working and becomes embedded. Too frequently wash water is not used in sufficient amounts to reach all parts, particularly the ends of the churn. Also, the rotation of the churn fails to force water against the ends.

Upon being asked why butter sticks to the churn, an efficient operator replied, "Pardon me, but if your churn is clean, butter will not stick to it." That reply is brief and to the point. It also states all the facts. The following outline for washing churns is suggested:

1. Rinse all visible butter from the churn with water at 120° to 140° F., and preferably make two such quick washings with limited amounts of water.

2. Fill the churn one-third to one-half full of water at 180° F., and rotate the churn 15 to 20 minutes. (Have vent open.)
3. Drain churn with door down for 15 to 20 minutes, rotate to filling position, and place screen over door opening. See that all other vents are closed to prevent insects from entering.
4. Use a mild soda washing powder about once a week to insure thorough removal of fat. Caustic soda in particular is to be avoided. It is too severe. One churn manufacturer objects to the use of trisodium phosphate in churns.
5 Use a plentiful rinse of chlorine solution 50 to 100 p.p.m. about twice a week or as conditions indicate.

Always rinse washing powders and chlorine solutions from the churn with sufficient amounts of hot water, and drain and dry the churn as indicated above. Daily use of washing powders should not be necessary and may tend to produce a milkstone-like coating on the wood to which fat may adhere.

Below we quote from U. S. D. A. Circular 294 by Winkjer, Burns, and Burke giving directions for washing the churn. If any changes were to be suggested in their recommendations, they would be: (1) use more water, at 180° F.; (2) rotate the churn 10 to 15 minutes instead of 4 minutes.

> The method of washing the churn is a good example of direct savings. Washing the churn properly is a simple procedure. Immediately after removal of the butter, rinse the churn with about 25 gallons of water at 130° F. In the second rinsing use the same amount of water at 130°, and add about 1 pint of a good dairy washing powder. In the third washing use at least 30 gallons of water at 212° (boiling hot) and run the churn 4 minutes. Open the doors and turn the openings down, letting the water out quickly. After a few minutes, turn the churn so that the openings are on top again, and let it stand with the doors wide open, so that it can dry while still hot.
>
> This procedure is simple enough, but failure to follow it closely will result in butter sticking to the churn, which is a common trouble in southern creameries and a cause of much loss of butterfat. In fact, waste of butter from this cause constitutes one of the greatest losses, while it should be one of the minor losses when the churn is washed properly.

Cleaning Neglected Churns: When neglected churns fail to respond to mild washing powders, stronger alkalies and greater concentrations may be used. Rock salt with some water has been used quite successfully to rasp the wood surface. This fails to reach the under side of shelves and the ends of the churn. A brush should be used on the accessible parts of the churn. Sulphuric acid which is used for cream testing may be resorted to in very stubborn cases. Use it at the rate of 1 quart to 100 gallons of water. Experience has proved that this is definitely to be avoided if possible. It has severe corrosive action on all metal parts within the churn.

General Outline of Churning Procedure:

1. Hold the cream at least 2 hours before churning. (Shorter holding periods require temperatures several degrees below churning temperature.)

   a. To insure proper fat solidification.
   b. To avoid quick churning with accompanying high fat losses in the buttermilk.
   c. To insure butter of firm body.
   d. to facilitate composition control.

2. Make a vat fat test of the cream to check intake work.
3. Make an acidity test of the cream just before churning.
4. Adjust the churning temperature so that churning is completed in 45 to 60 minutes. (This requires consideration of all the factors discussed under "Factors Affecting the Churnability of Cream,") p. 197.
5. Add butter color to approximate the color of butter in June.
6. Churn until fat granules are too large to pass through the churn screen. Draw buttermilk. Take a sample for both acid and fat tests, catching some at 3 or 4 intervals in order to get a representative sample. Record temperature of buttermilk.

Spray the butter with cold water from the hose to remove the buttermilk more completely before adding bulk wash water. Use wash water strained through cloth. Adjust temperature to the same temperature as the buttermilk if consistent with the firmness of the butter. If the butter is soft, use water a few degrees colder (2 to 6° F.). If incorporation of moisture is judged probably difficult, use warmer water (2 to 6° F.). Extremes of 10 to 12° F. may be used if deemed unavoidable but only in case the butter granules are not larger than corn kernels. The amount of wash water should be about the same as the amount of buttermilk. Rotate the churn about ten revolutions. (For sticky butter see reference 7.)

7. Drain all wash water thoroughly. Draw the last through the door.

8. Work the butter a few revolutions to gather into a mass on the shelf.

9. Add salt at the rate of 3 to 4 pounds per 100 pounds of fat. Place in trenched butter evenly and cover trench. In a two-door churn best results follow weighing the salt in two even batches to insure equal amounts in each end of the churn.

10. Work the butter and salt 20 to 30 revolutions. Run first moisture test. Calculate water to add to raise the moisture per-

CHURNING RECORD

Date........	Churning No.........
Operator........................	
Pounds cream........ Fat........	
Raw cream acidity............	Acidity reduced to....................
Churning acidity.............	Neutralizer used......................
Buttermilk acidity............	
Pasteurizing temp.............	
Time..........	
Time held before churning..........	
Churning temperature..........	Churning time............
Rate of coloring........ Amt......	Start....... Finish....... Time.......
Condition of butter at washing.......	
....	
Temp. buttermilk....... % fat.....	Rate of salt........ Amt.........
Temp. wash water....................	
Method of salting.... Wet.... Dry....	Moisture tests
Revolutions worked	
Before salting.....................	1st........ 2nd........ Final........
After salting.....................	
Starter used........	
Ripened...... Time...... Temp......	Pounds butter made...... % O.R......
Fridays..........................	
Fridays..........................	
Tubs.............................	
Tubs.............................	
Jars.............................	
Jars.............................	
Scraps...........................	

centage in the butter to 15 and place in the churn. Work 20 to 30 additional revolutions.

11. Run second moisture test, compute, and add water to raise the percentage to that desired in the finished butter (80 per cent fat must be maintained.)

12. Total working of 60 to 100 revolutions should suffice. Variations are often used, depending upon the make of churn and the particular methods of processing.

13. Final moisture tests should always be run at finish of working and before placing butter in final package.

Salt tests are strongly advised at the time of making the final moisture test. Greater assurance of complying with legal requirements is afforded. (Note. Detailed churning records should always be made.)

QUESTIONS

1. Describe the physical condition of fat in cream.
2. What are the continuous and discontinuous phases in cream? In finished butter?
3. Contrast Rahn's foam theory with the concussion theory of butter formation.
4. List some of the important fats in butter with respect to influence on churning temperatures. Give their approximate melting points.
5. Why is olein so important from the standpoints of:
   a. Churnability of cream?
   b. Length of holding period of cream?
   c. Temperature of cream during holding?
6. List in order of their importance, the factors affecting the churnability of cream.
7. Discuss each point separately.
8. How are churn speeds determined?
9. Discuss optimum churn speeds in relation to centrifugal force in the churn and excessive wear and power requirements.
10. What is the advised minimum holding period for cream after pasteurizing? Why?
11. What butterfat content of cream produces the most desirable churning results? Why?
12. List some causes of difficult or delayed churning.
13. State the interrelations of churn diameter, churn speed, and churning temperatures.
14. List some factors causing excessive buttermilk fat losses.
15. What is an average of buttermilk fat losses in winter? In summer?

16. What recent stimulus has induced the general practice of straining and filtering cream?
17. Compare lime and soda neutralizers as they affect the filtering of cream.
18. Discuss the proper preparation of a new churn before use.
19. What two kinds of butter color are used?
20. What is the purpose of coloring butter?
21. What are the objections to overchurning or underchurning?
22. Outline a good method of washing churns.

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CHAPTER 11

WASHING, SALTING, AND WORKING OF BUTTER

WASHING

Purpose of Washing Butter. Butter is washed to remove as much buttermilk as possible. This enhances keeping quality. Butter from second-grade cream may be washed two or three times to remove the buttermilk more completely and possibly to reduce off flavors.

Condition of Butter for Washing. Butter must be churned until the granules are large enough so that a minimum amount of fat is lost when the buttermilk is drawn. Thin cream requires more time to churn sufficiently after the butter breaks and especially so if the temperature is normal or slightly below normal. Butter granules may be round or of a flaky nature but in no case should they be larger than corn kernels. If larger, a condition termed "overchurning" exists. This condition produces higher curd content in the butter and keeping quality is lowered.

Wash-Water Temperatures. Wash water should be as near the temperature of the butter and buttermilk as possible. At certain seasons of the year, because of harder or softer butterfat, wash water is often varied 4° to 6° F. in order to temper the butter and better control its composition. In that event, it is advisable to leave the water on the butter longer in order to temper it thoroughly.

In extreme cases wash water which varies 10° to 12° F. may be used, and again the importance of allowing sufficient time for tempering must be emphasized. Such extremes should be avoided and should be used only when the butter granules are sufficiently small to facilitate complete temperature equalization. The butter granules must be tempered throughout their entire mass. Such drastic variations from the buttermilk temperature are seldom used except to chill very soft butterfat. This condition of the fat demonstrates poor judgment in choosing churning temperatures and cream-holding temperatures. Such soft fat is also very readily overchurned, and the buttermaker too frequently gets into difficulty in composition control and mottles. If the butter granules are chilled on the outside and remain relatively soft near the center, it is difficult to avoid mottles.

The reader is here referred to Chapter 10 for a discussion of recent studies in controlling the body and texture of butter by differences in wash-water temperatures. Wash-water temperatures 15° to 18° F. below butter temperatures greatly improve the spreading ability of winter butter. As previously explained, churning temperatures are as high as consistent with a reasonable churning period. (Ref. 7, Chapter 10, Coulter and Combs.)

The accepted amount of wash water is that which approximates the volume of buttermilk in the churning. This will float the butter granules so that more complete washing is possible.

Wash-Water Tanks. Most creameries are now very careful about straining wash water through muslin or other suitable cloth to avoid rust flakes and sediment which may be in the water. Some creameries use tanks for preparing wash water. Large pipes leading from the tank conduct the water by gravity to the churn very quickly so that time is saved. The water is adjusted to the proper temperature in the tank. Brine or direct-expansion ammonia coils can be placed in the tanks for cooling the water in summer, or clean chipped ice may be used. A steam jet will temper the water for winter use. Great care must be used to keep these tanks absolutely clean. They should be partly covered to keep dust out. They should be ventilated to prevent stale odors. In smaller creameries the same tank may be used to heat wash water for the churn. This would tend to facilitate sanitation in the tank. If the tank is used for heating wash water, ammonia coils should not be installed.

Most city water supplies are tested for purity and are entirely suitable for use. If creameries have their own wells, they should have tests made periodically to determine the purity and safety of the water.

Effects of Alkali Wash Water. In some western states the question has arisen relative to the suitability of artesian or alkali water for use in washing butter. Larsen, White, and Bailey [1] found that salted butter scored practically the same when washed with alkali or hard water, normal water, and condensed steam. Unsalted butter scored about one point less after one week, and the flavor left by the alkali water was very readily recognized. Most western creameries use municipal water now, and it is very unlikely that alkali water needs to be considered.

Overchurning. Overchurning of butter presents washing difficulties. The churning should be stopped when the butter granules are sufficiently large to prevent mechanical loss in the buttermilk, i. e., when they are too large to pass through the screen. When the masses of butter are large, they mechanically enclose curd, and washing is incomplete. In such cases the workers may be engaged and the butter worked in the wash water to help remove some curd. In the season of soft butterfat, judgment must be used to avoid butter composition difficulties.

Body and Color of Butter Affected by Washing Temperatures. The foregoing discussion of wash-water temperatures is not intended to convey the idea that adjustment of wash-water temperatures is primarily a matter of butter-composition control. The practice of washing butter was no doubt started for the purpose of more complete removal of buttermilk. Later it was found that the butter could be tempered to some extent by changing wash-water temperatures. The science and skill of buttermaking today indicate that one of the most important considerations in varying wash-water temperatures is the effect upon the color and body and texture of butter. If butter containing higher percentages of hard fats is washed with water colder than the buttermilk, excessive working may be necessary. Continued working is likely to produce a lighter color and to cause the body to be sticky. Such butter is undesirable from the standpoints of lack of flavor and its spreading property. On the contrary, many market buyers are printing increasingly large quantities of butter. They use mechanical printers and the butter passes under pressure to the cutter. If butter is not well worked, appreciable quantities of brine are pressed out. This represents printing losses which are objected to. If the buttermaker tries to fulfill the demands of printers, he may overwork the butter and sacrifice some of the desirable and spreading qualities. As a result, the buttermaker finds himself compelled to decide whether he will please the printers regarding losses or please the consumer with a more palatable and more easily spread butter.

Lower wash-water temperatures permit the butter to be worked more without serious injury to its body. Extremes must be avoided. Excessive working of extra firm butter injures its body because of a shearing action of globule over globule of butterfat. Experience in making and judging butter are essential for the operator who acquires the ability to make a good product.

SALTING

Object of Salting Butter. Butter is salted to increase its flavor and to promote keeping quality.

Amount of Salt to Use. The usual amount of salt added to butter is 3 to 4 pounds per 100 pounds of fat. This leaves 2 to 3 per cent of salt in the finished butter. Three per cent of salt is considered by most buttermakers to be sufficient for flavor demands of any market. It has also been proved experimentally that greater amounts will seriously reduce keeping quality. In fact, 2.5 per cent salt is a better limit for butter of any quality. Butter made from average cream will usually store better if it has about 2 per cent of salt, whereas butter from fine cream will store well with 2.5 per cent of salt. Second-grade butter often scores better when fresh if it contains no salt at all. A medium salt content accentuates flavors, and second-grade butter may score less when salted. It is sold unsalted only to special markets. Such unsalted butter is usually made from ripened cream to augment its flavor. The Jewish trade demands such butter. Butter on the London market from various exporting countries is rather mild in salt and is somewhat lighter in color than American Butter.

An additional consideration in ripening unsalted butter is the influence of a higher acid content on its keeping quality. In the absence of the preservative properties of salt, ripening of cream is practiced (0.40 to 0.45 per cent) to inhibit growth of certain putrefactive types of organisms. Please refer to Chapter 9, "Starters and Cream Ripening."

Methods of Salting. The salt is usually placed in trenched butter, being distributed evenly from end to end of the churn. The trench is closed and the working started. The salt may be used dry or it may be made into a salt mash before being trenched in. The latter method starts the solution of the salt and may facilitate proper incorporation of moisture, whereas dry salt would at first tend to withdraw moisture from the butter. This method is often used during the fall and winter when butterfat is more firm and delayed moisture incorporation might result with dry salting. Water used for the salt mash must be deducted from the total amount of water calculated to be added to the churn for moisture control.

Some buttermakers work the salt with the butter a few revolutions before adding water. This is likely to secure added benefits from trenching, and less salt may be wasted by entering the wood of the churn as brine. When butter is salted at the rate of 3 pounds of salt to 100 pounds of butterfat, the butter may contain theoretically 2.4 pounds per 100 pounds of finished butter.

$$3 \div 100 = 3 \text{ per cent of salt on fat basis}$$
$$3 \div 125 = 2.4 \text{ per cent of salt on butter basis}$$

A pound or more of salt will soak into the wood of the churn, and, when some water remains in the churn after working, the salt content of the butter may be 2.2 to 2.3 per cent. This is considered enough, particularly from the standpoint of storage.

There are other factors also in this apparent loss of salt between the amount added and the amount recovered in the butter. Salt may be stored in a damp place. A pound of such salt would cause a greater apparent loss than dry salt. Slight impurities in salt also cause some additional apparent loss.

There is some apparent loss of salt in the all-metal churn. This is accounted for as explained above. Obviously, the churn itself could absorb no salt.

It is very important that equal amounts of salt be placed evenly in both doors of a two-door churn. Experiments at the Minnesota station disclosed considerable difference in the salt content of butter when the amount of salt was distributed by guess as compared with weighing two equal batches. In the newer single-door, short-barreled churns, the danger is not so great. The importance of this point, however, should not be overlooked.

Salt added to butter in rollerless churns may or may not be embedded in the butter. The makers of some of these churns state that trenching is not necessary. It is possible that trenching may cause slightly less waste of salt. It would seem desirable to trench if salt mash is used. The Jensen all-metal churn has a special opening near the top. This is used to transfer the cream to the churn, to add color, and to add salt. The door of the churn remains closed. This is an advantage where an insect menace exists.

Salt in Relation to Water in Butter. Experiments have demonstrated that pure fat is not a salt-dissolving substance. Owing to this fact, the only salt-dissolving substance in butter is water. As water will hold only a certain amount of salt in solution, it becomes evident that the amount of salt which can be properly incorporated in butter depends upon the amount of moisture present.

The amount of salt which water will hold in solution at different temperatures varies somewhat according to different investigators. According to Gerlach[2] water will dissolve 35.94 per cent of salt at 58° F. This is approximately the temperature at which salt is worked into butter. Theoretically, butter containing 15 per cent of water should be able to dissolve 5.4 per cent of salt properly. Butter containing 13 per cent of water should be able to dissolve 4.86 per cent of salt properly, and butter containing 10 per cent of water should be able to dissolve properly 3.6 per cent of salt, etc. According to experiments conducted at the Iowa Experiment Station, the maximum percentage of pure salt (NaCl) that could be properly dissolved in water of butter containing 16.92 per cent of moisture, when worked 18 revolutions at intervals during two hours, was 16.57. When butter was worked the same number of revolutions at intervals, and the salt was allowed to dissolve only one hour, the amount of pure salt (NaCl) that was dissolved in the water of the butter containing 11.58 per cent moisture was 14.09 per cent. This undoubtedly will vary with different brands of salt.

It will thus be seen that the property of water to take up salt is seemingly lessened when the water is present in a state of minute division, as it is in butter. In the first instance quoted, the water in the butter completely dissolved about 2.7 per cent of pure salt; and in the second instance it dissolved only about 2 per cent during one hour.

From the foregoing it is evident that, where butter contains a high percentage of salt, the salt may not be thoroughly dissolved. Undissolved salt causes gritty butter.

Mottles or uneven color is also caused by the presence of undissolved salt. Water tends to migrate to points of greatest salt concentration. The presence of more brine near undissolved salt produces darker spots or mottles. (See p. 251 of this chapter, under heading "Working.")

Kind and Condition of Salt. Salt for butter should be fine and readily soluble, so that it will be completely dissolved and incorporated when the working of the butter is completed. But fineness alone does not determine solubility; some salts that do not seem very fine are quite readily soluble, because the crystals are somewhat flat and dissolve quickly. Again, good dairy salt is white and clean in appearance. When it is dissolved in a cylinder of water there should be no settlings and nothing left floating on the surface of the water.

Brands of Salt. Hunziker, Cordes, and Nissen[3] in 1928 studied ten standard butter salts. They found no differences in their effects on flavor, body, and color of butter made. The addition of $CaSO_4$, 3 per cent KCl, 1 per cent $CaCl_2$, and 1 per cent $MgCl_2$ to these various salts did not produce noticeable flavor defects. Some of the salts produced turbid brines, which was considered objectionable. All the salts were very pure from the standpoint of bacterial content. The salts were 98.34 to 99.69 per cent pure NaCl. Calcium sulphate from 0.01 to 1.22 per cent was the largest chemical impurity. Solubility rates of brands and of cube and flake salts appeared to be relatively unimportant, since all dissolved readily.

Effect of Salt on Keeping Quality. Butter for storage should not have the extremes of salt content which may be used in other butter. In general, it appears that a salt content of 1.5 to 2.5 per cent is a very suitable range for storage butter. Salt has a well-known preservative effect and inhibits the growth of microorganisms. It is therefore beneficial from this standpoint. On the contrary, we have sufficient experimental work which shows that higher percentages of salt stimulate chemical changes in storage butter and that it is therefore detrimental to keeping quality.

Gray and McKay[4] found that lightly salted butter had superior keeping quality.

Washburn and Dahlberg[5] in 1918 found that salt exclusive of its antiseptic properties, hastened the deterioration of butter in storage except at temperatures below 0° F. Both chemical and biological changes were arrested at lower temperatures and little difference in scores was noted.

Sommer and Smit[6] in 1923 stated that salt is one of the factors which contribute to the development of fishy flavor in butter. Lecithin dissolves in salt solutions, and salt accelerates the change of lecithin into trimethylamine, which is the fishy-flavored substance. Several other factors are involved, and the mere presence of salt and lecithin does not predicate the development of fishy flavor. In fact, fishiness is not a common flavor defect of butter. Factors favoring the development of fishy flavor are:

1. Raw cream.
2. High-acid cream.
3. High salt.
4. Overworking.
5. Presence of iron and copper salts.

Macy, Coulter, and Combs[7] in 1932 found that salt checked the growth of yeasts and bacteria. Its inhibitive effects on mold were less marked. Higher percentages of salt were more effective in reducing the numbers of organisms.

The antiseptic properties of salt are, no doubt, the important considerations here. Since the deterioration of butter in storage is caused both by microorganisms and chemical factors, we must not use salt in such quantities as to stimulate chemical spoiling in an attempt to reduce deterioration from the activity of microorganisms. Furthermore, the presence of mold on butter is a much more important defect from the market standpoint than flavors resulting from yeast and bacteria. All attempts must be centered on preventing the contamination of butter from churn, packing tools, parchment, and containers rather than the use of salt as a preventive measure.

Thornton and Wood[8] in 1935 also concluded that salt is an important inhibitory factor in the growth of microorganisms in butter. They present data which show that parchment paper is best treated in saturated salt solutions, either hot or cold, and that dry, carefully protected parchment and wet sterile parchment are less effective, in the order given. This work with parchment has reference to mold growth.

Guthrie, Scheib, and Stark [9] in 1936 stated that their results confirmed previous experimental work which showed the inhibitory action on microorganisms of lactic acid and salt in butter.

The presence of either lactic acid or salt in butter not containing other spoilage factors considered in their study resulted, after storage, in a poorer quality of butter. The combined effect of salt and acid is shown by lower scores after 36 days storage at 10° C. (50° F.).

Although the conditions of storage here are far different from those of commercial storage, both fresh and storage butter are stored in retail stores and homes under comparable conditions before being consumed, and keeping quality is an important consideration. The amount of salt in their samples ranged from 2.05 to 2.36 per cent. This is probably less than the average salt content of creamery butter.

It is interesting to note here a regulation for Canadian butter regarding the percentage of salt it may contain. *

> Salting . . . must be all dissolved and not over 2 per cent salt, unless the butter is destined for a purchaser who requests over 2 per cent salt. First grade certificates issued for butter containing more than 2 per cent salt shall bear the following notation: "As the butter for which this certificate is issued contains more than 2 per cent salt and is represented as being for a trade requiring more than 2 per cent salt, a First Grade certificate has been issued. This certificate is not valid for sale of the butter for either export or domestic trade except to a purchaser requesting a salt content of more than 2 per cent."

It is quite evident that Canadian authorities consider more than 2 per cent detrimental to keeping quality. It may be that the keeping quality of Canadian export butter was the chief concern of officials. If so, this is quite in accord with the experiences of New Zealand, Australian, and Argentine exporters of butter.

* The Dairy Industry Act and Regulations (as amended to June 6, 1936) J. F. Singleton, Dairy Commissioner and Hon. J. G. Gardner, Minister of Agriculture, Ottawa.

The Land O'Lakes Creameries, Inc., reduced its standard for salt in butter from 2.5 per cent to 2.0 per cent in March, 1937.

From the foregoing references and discussion, we might summarize thus:

1. Salt is desirable in most creamery butter because of consumer preference.
2. It inhibits growth of microorganisms.
3. It checks mold growth, which is important in marketing.
4. High salt content may, and frequently does, accelerate deterioration of butter.
5. High salt in high-acid butter is definitely more detrimental than in low-acid butter.
6. Salt content of 2 to 2.5 per cent is recommended in sweet cream or first-grade cream butter.
7. Less than 2 per cent salt may be more suitable for second-grade cream butter. Some of this butter may have a sales advantage if entirely without salt.

WORKING

Objects: Butter is worked to insure a more uniform composition and to produce a desirable body and texture. These are desirable from the numerous standpoints listed.

1. Overrun.
2. Marketability.
   a. Flavor; more uniform and palatable.
   b. Color; uniform, avoiding mottles and waves.
   c. Body and texture; to prevent leakiness, shrinkage, and printing losses.
   d. Salt; even distribution, avoid mottles, solution of, avoid coarse briney flavors.
3. Maintenance of legal composition—not less than 80 per cent butterfat.

Firmness of Butter and Amount of Working. The time required to churn helps the operator to judge the firmness of butter. The wash-water temperature is determined by the firmness of the butter and its condition after the buttermilk is drawn. The washing of butter is based on the conditions just stated. In all these operations no definite instructions can be given. The experience and good judgment of the buttermaker are exceedingly important.

Soft butter should be scrupulously avoided. It may not stand enough working to insure uniform composition and the body may be greasy. It is frequently leaky owing to lack of working.

Firm butter is much easier to handle. It can be worked enough to accomplish the purposes of working. Slight overworking or underworking is relatively unimportant. A good operator once ad-

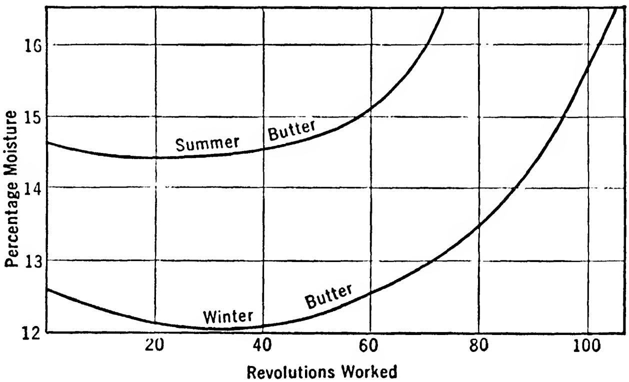


FIG. 68. Theoretical graph: Amount of working and rate of moisture incorporation; summer and winter butter compared. Original moisture content, amount of working, and rate of moisture incorporation depend largely upon fat consumption. See "Factors Affecting Churnability of Cream."

vanced the slogan, "Keep the cream cold and the butter firm, and work it plenty." A word of caution is necessary, however, because sticky butter may result from excessive working.

The composition of butterfat, which depends primarily upon the feed of cows, is the most important consideration. During the fall and winter, when dry feeds are used, butterfat is much harder. (See Fig. 68.) Coulter and Combs [10] recommend that cream be cooled but little lower than churning temperature if the cream is to be held overnight. Churning temperatures should be as high as is consistent with exhaustive churning. They point out that these recommendations are for winter butterfat only.

Butterworkers. Two general types of combined churns and workers are being sold. The merits of all types of workers are

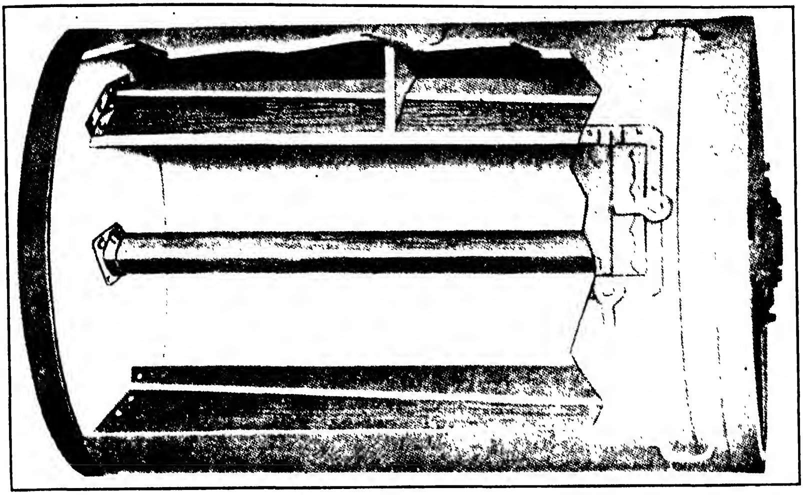


FIG. 69. Crano Churn; cut-away view showing new-type construction, no rolls. Courtesy Crane Company.

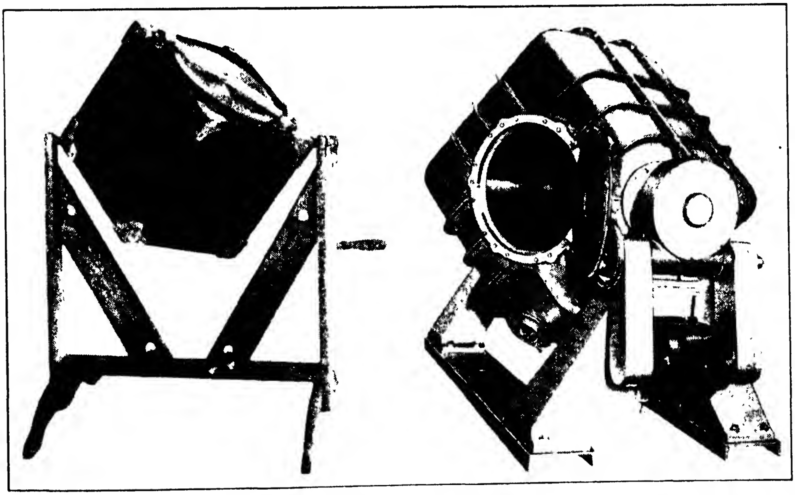


FIG. 70. Jensen—all metal—rollerless—aluminum alloy churn (right). The most recent model has interior ribs (no exterior) for strength and to facilitate churning and working. The four free corners are flattened. It has both churning and working speeds. Courtesy Jensen Creamery Machinery Co., Inc.

NOTE: The old hand churn (left) illustrates a method of agitating and churning cream, now re-employed in the Jensen all-metal churn.

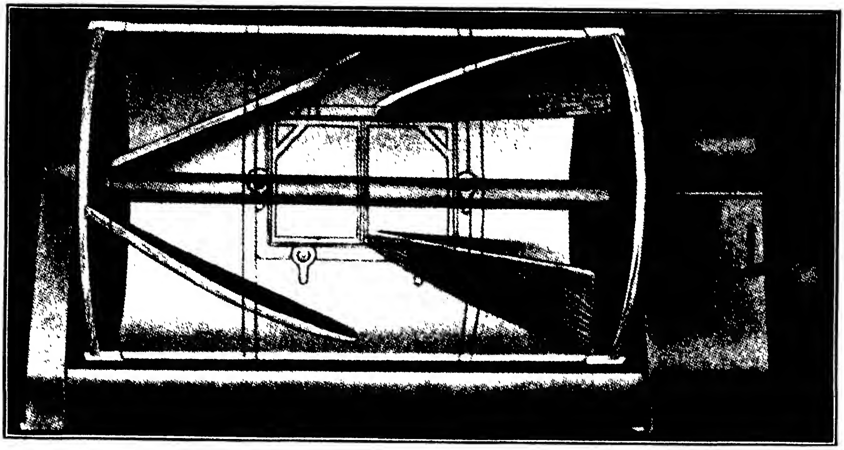


FIG. 71. The Vane Churn; phantom view showing position of vanes. Courtesy General Dairy Equipment Co.

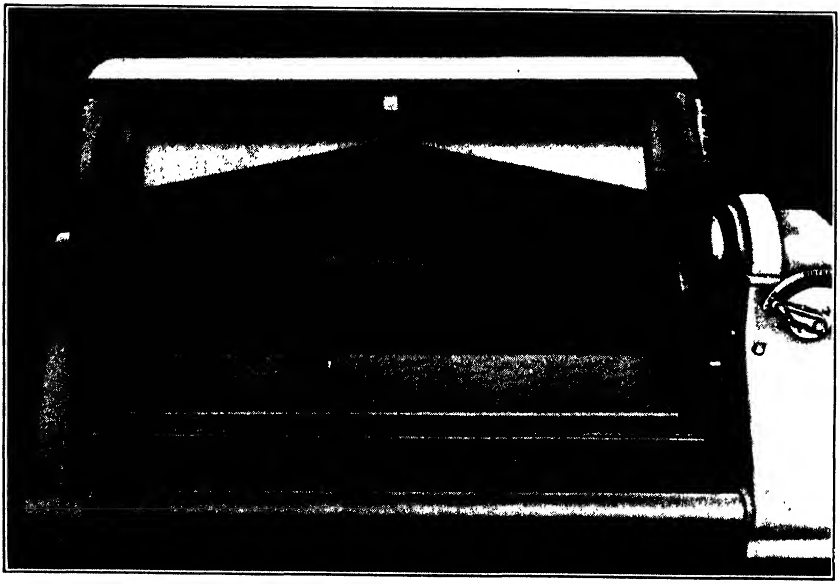


FIG. 72. New Sani-Drum Churn exhibited for the first time at the Dairy Industries Exposition, Cleveland, Ohio, October, 1938. Courtesy Cherry-Burrell Corporation.

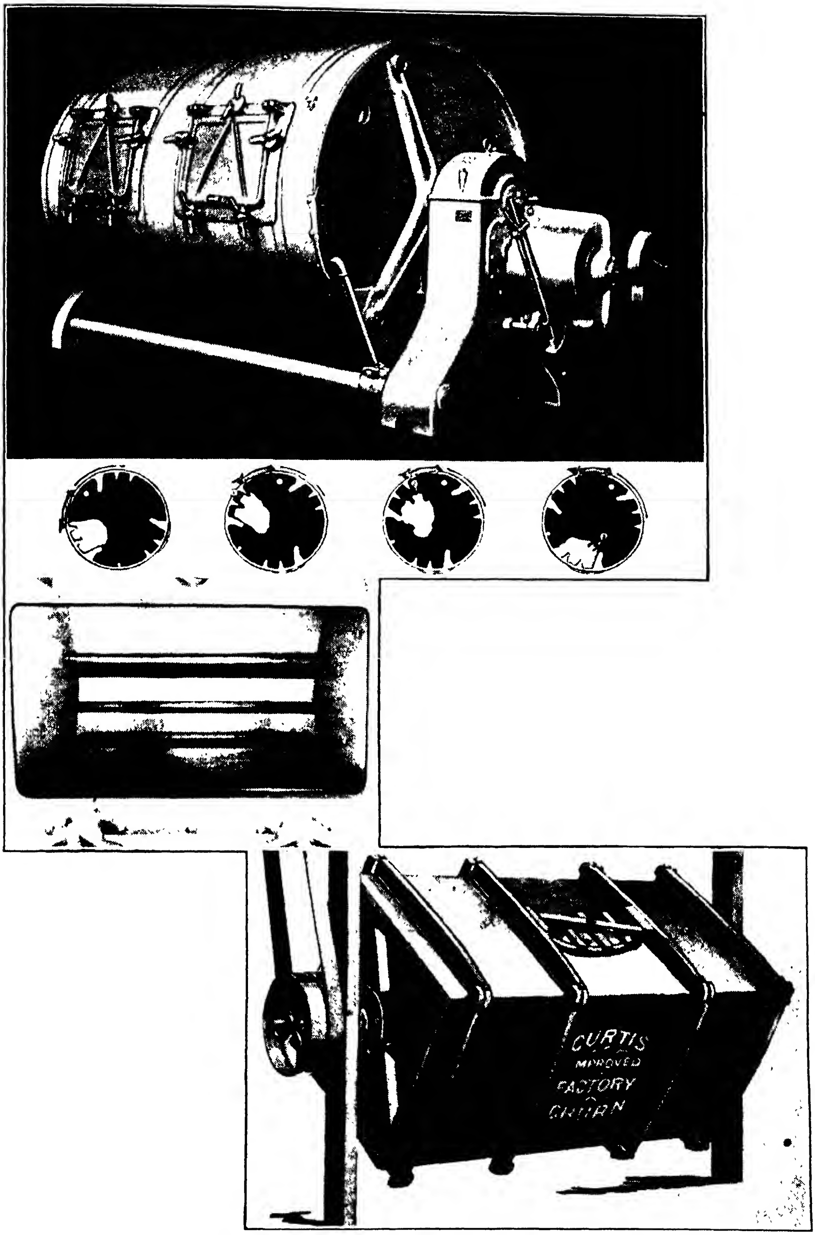


Fig. 73. New no-roll churn (top) interior view of no-roll (center). The square box-churn (bottom) built by David Curtis at Fort Atkinson, Wisconsin, in 1884. Built by the Creamery Package Manufacturing Co. and used for 10 to 15 years. The butter was removed from the churn and worked on a table. The Disbrow combined churn and worker was invented in 1890 and gradually replaced the old Curtis churn. Courtesy Creamery Package Manufacturing Co.

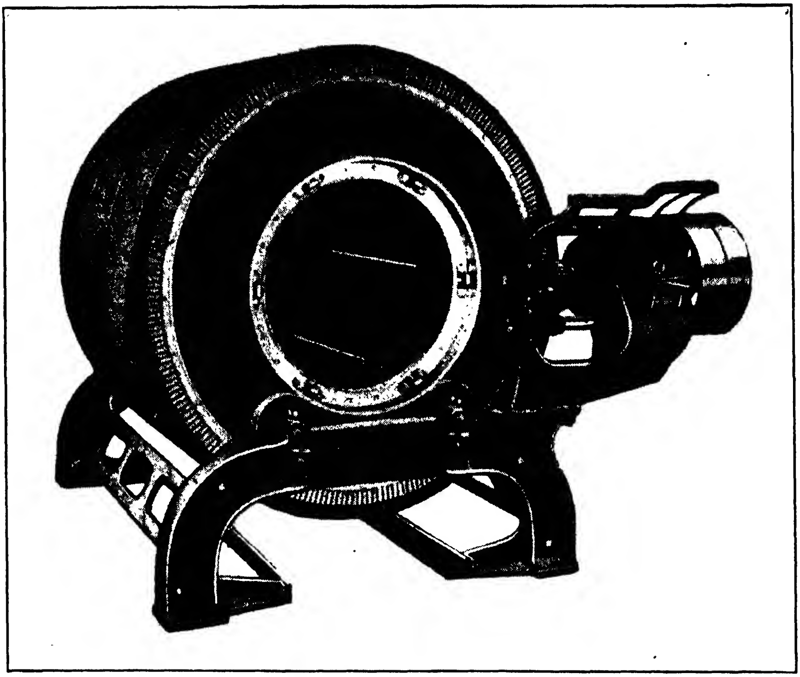
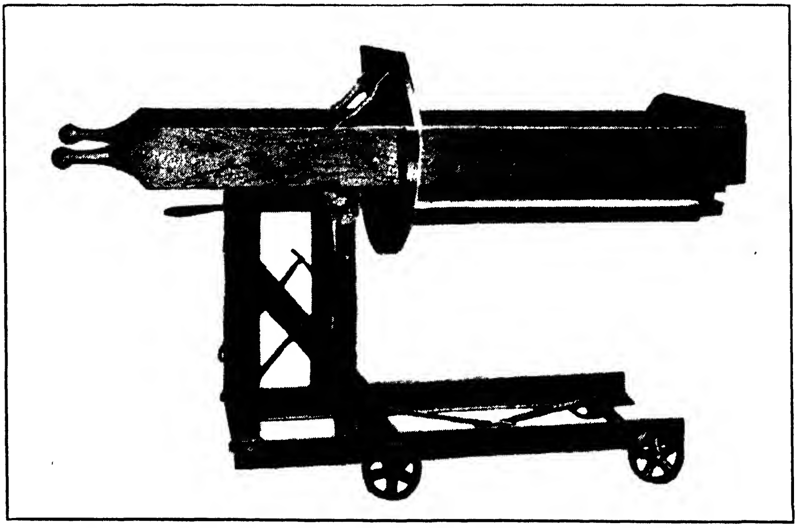


FIG. 74. The Simplex Churn has not been manufactured since 1927. Those in use today seldom use the worker rolls, which are mounted on a separate truck. Butter is worked by movement caused by the six internal shelves.



Truck with worker rolls; formerly used for working the butter and removing it from the churn. Courtesy Cherry-Burrell Corporation.

not definitely known. As with other trade goods, buyers select according to their individual judgment, or on the basis of experience of other users.

TYPES OF BUTTERWORKERS

Roller type	1 roll—Cherry-Burrell Co.
	Cherry
	2 roll—Creamery Package Manufacturing Co.
	Victor, Dual, Disbrow
	Cherry-Burrell Co.
	Simplex
	3 roll—Crane Co.
	Crano
	4 roll—Creamery Package Manufacturing Co.
	Victor
Rollerless type	General Dairy Equipment Co.
	Vane
	Crane Co.
	Crano spiral
	Jensen Creamery Machinery Co.
	Jensen, all-metal, aluminum alloy churn
	Sanitary No-Roll (new, October, 1938)—Creamery Package Manufacturing Co.
	Cherry Sani-Roll (new, October, 1938)—Cherry-Burrell Corp.

NOTE: In October, 1938, the manufacture of the Crano-Spiral churn was discontinued. Two new rollerless churns were exhibited for the first time at the Dairy Industries Exposition in Cleveland, Ohio, October 17 to 21. These were exhibited by two leading churn manufacturers, viz., Cherry-Burrell Corporation and the Creamery Package Manufacturing Company.

All the roller-type workers are built in the churns with the exception of the Simplex. In this churn, a large round door is provided and, when the butter is ready for working, the rollers, mounted on a floor truck, are entered through the churn door opening and a mechanism is engaged with the churn drive. Six shelves in the churn raise the butter in portions, to a level where it slides onto the rollers. It passes through the rollers and is picked up by the empty shelves as the churn rotates. The same shelves effect the churning as well, in much the same lifting manner. The Simplex churn has been discontinued since the D. H. Burrell Company of Little Falls, N. Y., was absorbed into the Cherry-Burrell Corporation. The removable roller workers proved to be insanitary and difficult to keep clean. This is somewhat anomalous, for undoubtedly the removable feature was intended for more complete sanitation. Simplex churns now in use are operated without the roller workers. Very satisfactory results in the working of butter are obtained.

The number of rolls in a churn and the manner of working do affect, to a limited extent, the rate of incorporation of water with the butter. The degree of firmness of the butter, however, is the important consideration in any working.

Rollerless churns, excepting some now being introduced, produce an end-to-end or corner-to-corner movement of the entire load of butter. The time required to work the butter is greater. With roller churns, working is usually completed in 5 to 8 minutes of working time. With rollerless churns 10 to 16 minutes are usually required.

Rollerless churns, which cause a toward-center movement, produce butter of very uniform composition. Analyses of 6 or 8 samples from the same churning show remarkable uniformity, varying but a few tenths of 1 per cent. Such churns also have the adaptability of wide range in churn load. They are easily accessible for cleaning.

Roller churns also produce excellent results. There is possibility of greater variation in the composition of the butter if a careless operator places more salt in one end of the churn than in the other. Professor Combs at the Minnesota Dairy School has demonstrated experimentally that greater uniformity in composition results when salt is divided equally by weight and placed in the churn, in two-door churns. Churns must be level, or more moisture may be incorporated in the butter at the low end. Minimum load requirements appear to be much greater in roller churns.

Leaky Butter. Formerly much leaky butter was made. During the past fifteen years the market has demanded well-worked butter because it is marketed in pound and quarter-pound prints. Leaky butter has a considerable loss in weight when it is printed. More skill is required in working butter to a point where leakiness disappears and still avoid overworked, sticky butter. (See Fig. 75, which is presented in the hope that it may help correlate some of the considerations which must be kept in mind when butter is worked. No blanket recommendations or instructions can be given. During the various seasons of the year and in various regions, working conditions must be changed.) If butter is soft at the time of working, it is frequently leaky owing to insufficient working. Firm butter can be worked much more without becoming sticky.

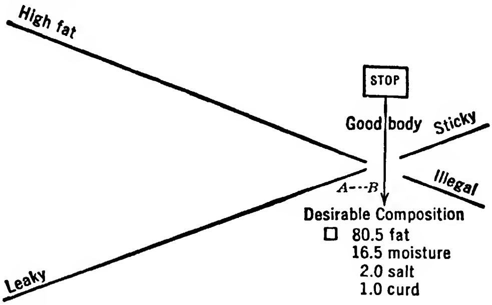


FIG. 75. Working of butter. Modern buttermaker must be skillful. He must:

1. Get near 80 per cent fat.
2. Preserve body.
3. Judge well.
    a. Butter firmness.
    b. Wash-water temperatures.

A -- B, danger zone.

Furthermore, firm butter will mechanically hold the tiny separated water droplets as pictured by Washburn and styled by him "new-type butter." (See Fig. 76.)

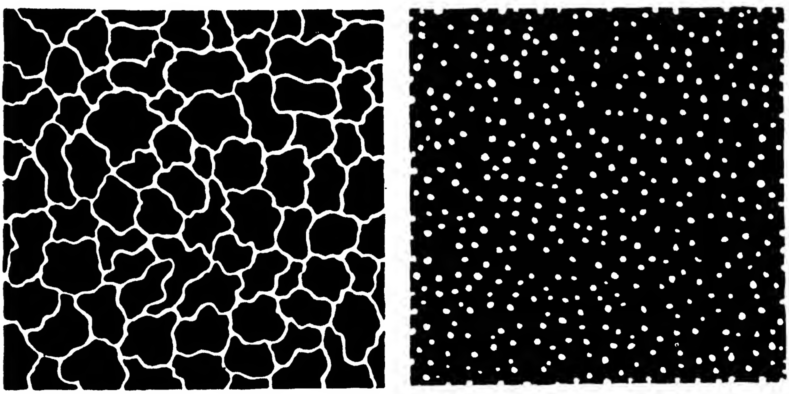


FIG. 76. Distribution of water in butter. The old (left) and the new (right) in butter. Colored matter represents the fat and white matter the spaces between the butterfat filled with water. In the old-time butter the fat granules are gathered in groups or clusters with the water between the clusters. In the new type the fat surrounds minute droplets of the water. The old will leak water when cut and the new will not. Courtesy R. M. Washburn and the *National Butter and Cheese Journal*.

Variations in Butter Composition in Butter from One Churning. These graphs from data from Purdue in 1912 (Fig. 77) and from Iowa in 1937 (Fig. 78) indicate a surprising difference in the composition of butter from the two ends and the middle of the churn. In 1912 butter was worked much less than it is today and this might account for greater variation in composition of samples. However, the data from Iowa bulletin 358 (1937) shows much variation.

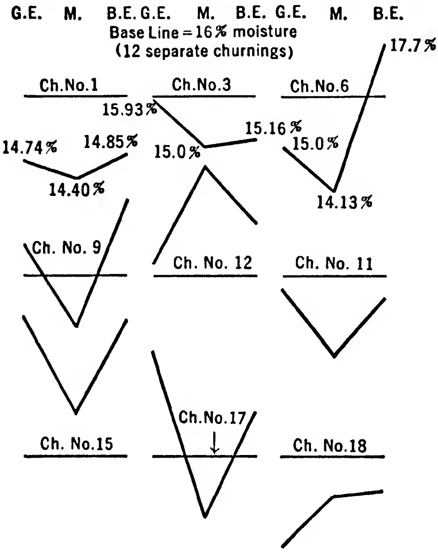


FIG. 77. Variations in moisture content of finished butter; data from Purdue Bulletin 160, 1912, Hunziker, Mills, and Spitzer.
G.E. = Gear end. M. = middle
B.E. = Buttermilk or gate end.
Ch. = Churning.
(Churnings are selected to show wide variations in moisture content.)

Lee, Hepburn, and Barnhart in 1909 (Ill. Bull. 137) state that common practice had been to work butter twelve revolutions in the Victor churn and eighteen revolutions in the Disbrow churn. Their data show that samples from the middle of the churn are somewhat lower in moisture and higher in fat than those from either end. All moisture tests ranged mostly between 13 per cent and 15.5 per cent, showing incomplete working as judged by modern practices. They occasionally had variations of one per cent in moisture content on samples of butter from different parts of the same churning.

The data presented in Fig. 77 from Purdue Bulletin 160 do not include all analyses made. It should be observed that certain churnings were selected and the analyses shown in graphical form. Those selected show the greatest variations. They were intentionally selected for the purpose of emphasizing possibilities or extremes. Attention to all details is necessary to avoid such conditions. In this bulletin, the authors indicate that great care in sampling butter is necessary and that the moisture content of butter should not be much above 15 per cent to avoid danger of having more than 16 per cent in some samples. (A federal regulation at that time limited the moisture content to 16 per cent.)

Churn manufacturers indicate that churns should be level when installed. Nevertheless, churns are neglected after installation and it is not uncommon to find one end of a churn lower. Some operators incline to the theory that the gate end of a churn should be slightly lower to facilitate draining of buttermilk and wash water. This is wrong. Water collects at the low point and the moisture content of butter in that section of a churn is usually greater. Excessive tightening of churn hoops at the center of long-barreled churns may actually make the center higher than the ends and may be a cause of lower moisture content in mid-churn samples of butter.

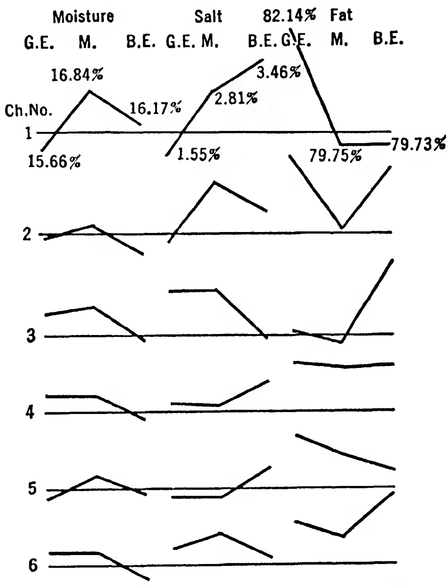


FIG. 78. Variations in compostion of finished butter; data from Iowa Bulletin 358, 1937, "Standardization of Iowa Butter," Mortensen, Breazeale, Meyer, and Michaelian.

G.E. = Gear end M. = middle
B.E. = buttermilk end.

The analyses of butter from a rollerless churn show remarkable uniformity. (See Fig. 79.) This is highly desirable. Later models of roller churns will, without doubt, give very satisfactory results because of shorter barrels. They should always be kept exactly level. Drainage of the last of the wash water should be done through the churn door and not from the gate.

Several considerations arise in a study of the uniformity of butter composition from a single churning.

1. What percentage of butter is of the desired composition?
2. Is lack of overrun caused by high fat percentage in a portion of the butter?
3. Danger of butter of illegal composition.

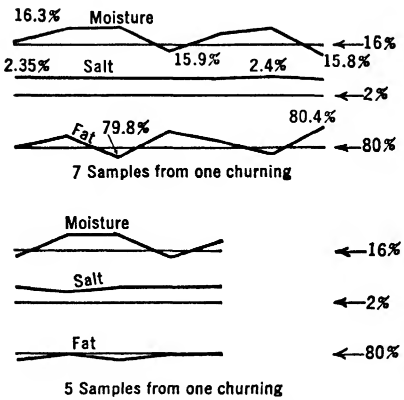


FIG. 79. Variations in composition of finished butter from *rollerless churn* (unpublished data, S. Dakota station), 1938.

Group of seven samples taken from different parts of same churning; 650 pounds of butter in 1000-pound churn.

Group of five samples taken from same churning; 100 pounds of butter in 750-pound churn.

Point No. 3 is probably of greatest concern to the creamery-man. The position of regulatory authorities is clear. Butter must contain a minimum of 80 per cent fat. No alibi is permissible. It is the responsibility of the operator to see that no portion of the butter is illegal in composition. He must see that the churn is level and that the butter composition is as uniform as possible. In addition he must use caution in approaching the legal minimum percentage of fat. Indications are that 80.5 per cent of fat is a sufficiently low standard to maintain.

Reworking of High-Moisture Butter. When the completed butter is of illegal composition (less than 80 per cent butterfat) the buttermaker must reduce the percentage of one or more of the three non-fat ingredients, viz., curd, salt, or water. Water is the most easily removed. As it is removed, the percentage of fat simultaneously increases. Again, referring to Washburn's pictures (Fig. 76), we see that butter with a texture indicated as "new type" may be worked in the churn until it assumes a texture resembling that called "old type." This can be done only after the butter has been cooled for several hours and is from 15° to 20° F. colder than when it was originally worked. Such butter is usually held in the cooler overnight. Most satisfactory results will be obtained if the butter is held long enough and in suitable-sized containers so the temperature will be quite uniform both at the surface and at the center of each unit. If held *en masse* on a truck, the butter should be cut into slabs about 6 inches thick.

When it is ready to be reworked, cut the butter into pieces which will pass between the rollers without causing excessive strain on the churn mechanism. The churn must be thoroughly soaked to prevent the butter from adhering to the wood. The butter may be worked several revolutions in water until it forms a rather uniform mass. The water is now drained thoroughly and salt is added to replace that which the water has removed. Usually one-third of the normal salt percentage is removed and must be replaced. Experience and good judgment are needed in this procedure. No fixed instructions can be given. This method is admittedly less exact but does lessen the tendency of butter being smeared on the interior of the churn and lost.

As reworking continues, moisture tests should be made in order that the operator may know when a legal composition is obtained. It is advisable to run a complete analysis of the butter being sure that a representative sample is taken for analysis.

The graphs which appear in conjunction with this discussion (Fig. 80) are intended to clarify a conception as to just what happens when butter is reworked. Two or more tiny water droplets

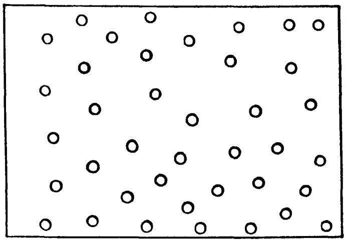
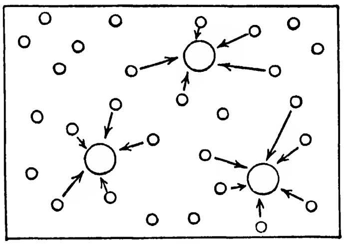
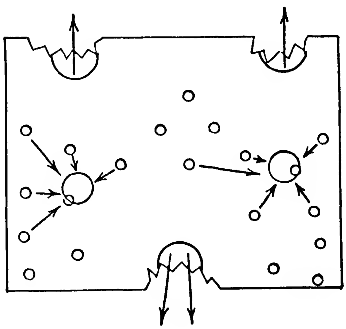


FIG. 80. Diagrammatical representation of physical changes in chilled butter when reworked to reduce its water content.

Low-fat butter—chilled, ready for reworking.



Partly reworked butter showing migration of tiny droplets.



Advanced stage in reworking, showing broken butter surfaces and drops of water being expelled by pressure as the working continues.

merge, forming a larger droplet. These in turn merge with others until sizeable droplets are formed. As working continues, these larger water units are forced to the surface of the mass of butter and escape. The butter is too firm to reincorporate much water, and the free water thus expelled is drained from the churn by stopping the churn when the door is underneath. Intermittent stops and continued working seldom fail to accomplish the removal of sufficient water.

Sometimes tubs of butter representing the product of several creameries and several different sections of the country may be reworked. This presents a problem because of:

1. Various shades of color.
2. Fats with different melting points; owing probably to different feeds (see also Chapter 10).

The butter may be tempered to 50° to 60° F. in a room where the temperature is in this range, or it may be tempered in water in the churn or in an open vat. In either case, several hours must elapse so the butter is evenly tempered. It is also advisable to reserve the lightest- and deepest-colored butters for separate workings. Because of the differences in melting points of these samples of butter, some will not be sufficiently soft to mix homogeneously so that mottled butter is frequently produced. The composition of the butter must be checked as working progresses. Good judgment must be used in the sale of this butter. Select customers who will understand explanations of its quality.

Amount of Working. Butter should be worked enough to insure even distribution of salt and moisture. The salt should be in complete solution and the moisture should be incorporated in relatively fine droplets. Firm butter requires much more working to accomplish the purpose. It will have a firm smooth body when finished and, if the working is carried to the proper point, will have the water droplets finely divided and firmly held. In this way leakiness will be reduced to a minimum. Packing and printing losses will be lowered and shrinkage in transit and storage is reduced.

Overworking should be carefully avoided. Overworked butter has a dull lifeless appearance and resists spreading on bread. Judges and buyers of butter readily recognize such a condition so that the butter usually sells at a discount. The butter clings to the trier, and considerable effort is required to remove the plug. Butter sticks to the trier because of the lack of free water droplets which would wet the trier and reduce the stickiness. Experience alone must be the guide to determine the amount of working.

Mottles in Butter: Causes and Prevention. Mottles in butter as well as waves or streaks are due primarily to insufficient working. There are several contributing causes:

1. Not enough working.
2. Butter of uneven temperature.
   a. Wash water too cold.
   b. Wash water too warm.
   c. Overchurning and wide variations in wash-water temperatures.
3. Overload in churn.
4. Underload in churn.
5. Rollers out of alignment.
6. Rollers out of mesh.
7. Churn not level.
8. Uneven addition of color to cream in churn.
9. Uneven addition of salt to butter to be worked.

Factors 8 and 9 may not produce typical mottles, but are likely to cause different shades of color in butter from the same churning. Butter from various parts of the churn, packed in the same container, will have layers with different shades. Even distribution in the churn of both color and salt is particularly necessary where long barreled churns are used. These points are of no significance with churns of the type of the Jensen (metal) or the Vane.

It should be stated at the outset that unsalted butter does not have mottles. The darker portion of mottled or wavy butter has a higher salt content. The higher salt content is accompanied by higher moisture, and the reduced fat content which results is the direct cause of difference in the refractivity of the rays of light as they strike the surface of the butter. Light rays penetrate deeper where there is less fat, and a deeper yellow color is reflected. The water droplets or brine droplets are usually larger where there is greater concentration of salt. This also permits light to enter the butter, and a deeper yellow color is reflected.

When wash water varies too much from the temperature of the butter and the butter is washed hurriedly, the particles of butter are chilled on the outside. The colder butter does not get worked so much, owing to its firmness. In addition, this firm butter will not incorporate water as rapidly as the softer portion. The result is a difference in composition and mottles appear in the finished butter. Mottles do not appear until several hours after the butter is packed. Time is required for the migration of water to the portions of greater salt concentration.

If the churn contains too much butter, a portion of the butter will pass over the workers and not between them. (See Fig. 81.) That portion, therefore, is not worked. Mottles are likely to be a result.

If the churn contains too small a load, the butter travels to one end and forms a cone-shaped mass. The small end of this mass passes between the rollers and is not worked. Again the way is paved for mottles and waves.

The rollers may not be parallel because of worn bearings or spindles. Some of the butter, therefore, is not worked so much where the rollers are farthest apart. (See Fig. 82.) In some chain-driven churns, like the Disbrow, the chain may slip cogs and the rollers would then be out of mesh. In replacing gears on gear-driven rollers, care must be exercised to see that the rollers are properly meshed.

If a churn is not level, there will be a tendency for the butter to migrate toward the low end so that uneven working takes place. In addition, water and salt (brine) in the churn will collect in the low end and the butter at this point will contain more moisture and salt. If waves do not result from differences in composition of the butter, there is still the objection of having two slightly different colors. One tub of butter packed from two or three different places in the churn may result in as many shades of butter in the same tub. Such butter does not sell to advantage.

In 1905, Van Slyke and Hart [11] made a study of mottles in butter stating that mottles were caused by the coagulating effect of salt on the curd in butter. They indicated that a thorough removal of buttermilk and curd would aid in the control of mottles in butter.

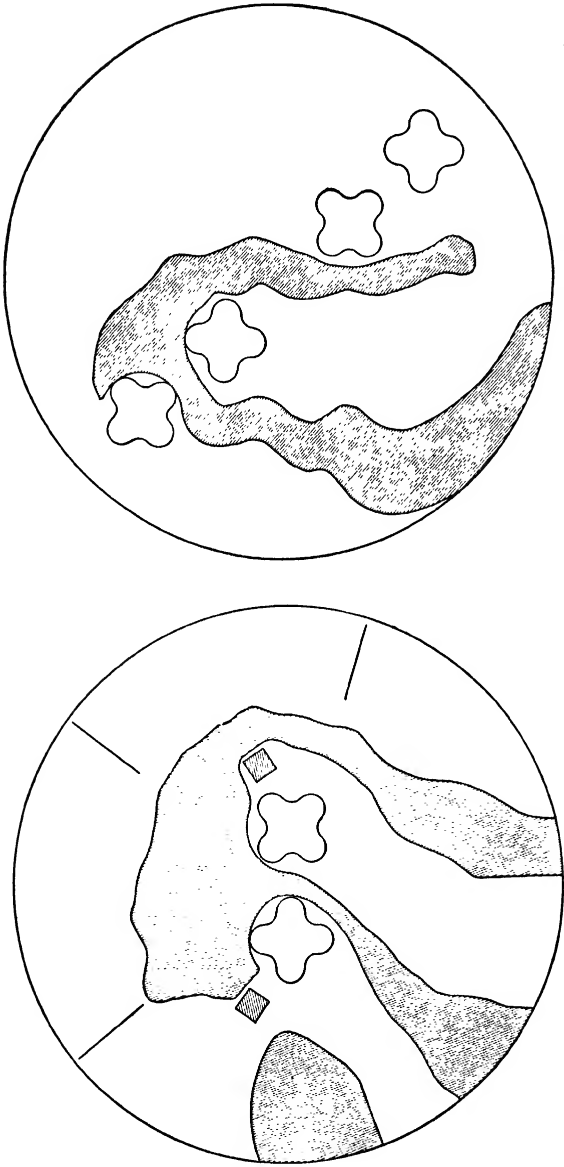


FIG. 81. Overloading the churn causes imperfect working and usually mottles. The butter passes over the rolls and not between them.

In 1912 Sammis and Lee at the Wisconsin station made a study of the cause of mottles in butter. Their work indicated that curd in butter was unrelated to mottles. They melted butter and filtered out all curd. This butter was then re-emulsified with water in a centrifugal emulsor and churned again. This curd-free butter had typical mottles when the working was not completed. The extent of mottling was greatest with the least working. This seemed to show quite conclusively that the uneven distribution of salt with consequent moisture migration was the chief cause of mottles.

A good class demonstration consists of removal of one-half

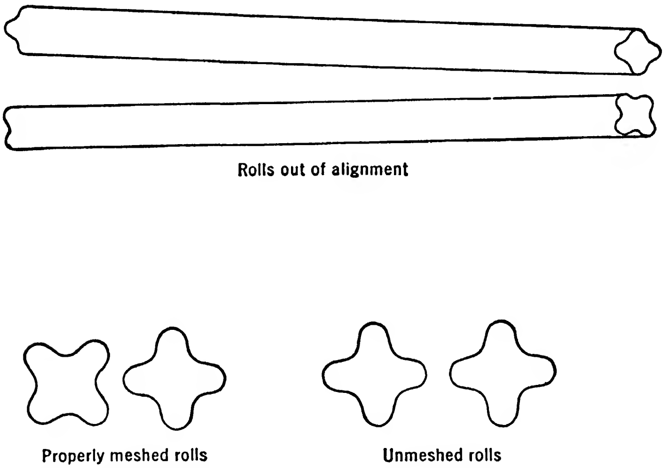


Fig. 82. Proper alignment and meshing of rolls is necessary for uniform working of butter.

pound samples of butter from the churn every 6 revolutions until 36 revolutions are completed. Hold these at least 48 hours. Then cut them in half and observe at what stage mottles were eliminated.

Moisture Control. The working of butter and efficient moisture control are two very important considerations in the technique of modern buttermaking. A thorough understanding of all factors is necessary. Intelligent experience is absolutely necessary. Maintenance of sufficient overrun and uniformity of product are mandatory under present competitive conditions. Haphazard and incompetent methods are definitely outmoded.

Efficient moisture control involves the use of some relatively exact formulas for computing the amount of water to add and incorporate in butter. A preliminary moisture test must be made. This can be done after the butter is drained and worked perhaps a dozen revolutions, or it may be made after the salt is added and a second dozen revolutions are made. The amount of water required for a standard composition is calculated and added to the churn. Some methods of calculation are given below. We will consider 632 pounds of butterfat in the churn and a desired butter composition of:

15.9 per cent moisture.
0.8 per cent curd.
2.8 per cent salt.
80.5 per cent fat.

The preliminary moisture test shows 12.9 per cent.

(1) Wisconsin Dairy Department [12]

$$\frac{(1.25 \times \text{fat})\ (dm - m)}{100} = \text{pounds water to be added}$$

[m = moisture dm = desired moisture]

Substituting

$$\frac{1.25 \times 632)\ (15.9 - 12.9)}{100} = 23.7 \text{ lb. water to be added}$$

(2) Winkjer, Burns, and Burke [13] [Salt added *after* first moisture test.]

632 ÷ 80.5 = 785.09 lb. finished butter
785.09 × 0.8 per cent curd = 6.28 lb. curd
632 + 6.28 = 638.28 lb. fat and curd
100 — 12.9 (preliminary moisture) = 87.1 or per cent fat and curd in partly worked butter
638.28 ÷ 0.871 = 732.81 or pounds of partly worked butter
785.09 × 15.9 per cent = 124.83 or total water in finished butter
732.81 × 12.9 per cent = 94.53 or pounds water in butter, when preliminary moisture test was taken
124.83 — 94.53 = 30.3 or pounds water to be added

Note: The mistake is often made of multiplying the total weight of finished butter by the amount of moisture shortage. The above problem would be 785.09 × 0.03 = 23.55 lb. water to be added.

(3) Winkjer, Burns, and Burke.[13] [Salt added *before* first moisture test.]

$632 \div 80.5 = 785.09$ lb., or total pounds finished butter
$785.09 \times 0.028 = 21.98$ lb. salt in finished butter
$785.09 \times 0.008 = 6.28$ lb. curd in finished butter
$632 + 21.98 + 6.28 = 660.26$ lb. fat, salt, and curd.
$100 - 12.9 = 87.1$
$660.26 \div 0.871 = 758.05$ total lb. unfinished butter
$785.09 \times 0.159 = 124.83$ lb. water in finished butter
$758.05 \times 0.129 = 97.79$ lb. water in unfinished butter
$124.83 - 97.79 = 27.04$ lb. water to be added

(4) Hunziker [14] uses a formula which for our problem shows 27.88 lb. of water to add.

(5) Figuring moisture to add to unfinished butter; method demonstrated by G. H. Wilster.[15]

$632 \times 1.235 = 780.5$ lb. butter expected (23.5 per cent O. R.)
$780.5 \times 0.028 = 21.85$ lb. salt (2.8 per cent salt)
$780.5 \times 0.008 = 6.24$ lb. curd (0.8 per cent curd)

Desired moisture in finished butter, 15.9 per cent.
Per cent fat lost during manufacturing, 0.72 (estimated).

$632 - (0.72 \times 632) = 627.45$ lb. fat available for butter
$627.45 + 21.85 + 6.24 = 655.54$ lb. (fat, salt, and curd)

Preliminary moisture test on partly worked butter, 12.9 per cent

$$100 - 12.9 = 87.1$$

$\frac{655.54}{87.1} \times 100 = 752.6$ lb. butter in churn at time of preliminary moisture test

780.5 lbs of butter expected $- 752.6 = 27.9$ lb. of water to add to the churn

(6) Calculations by G. M. Trout, and J. M. Jensen (modified Hunziker formula)[16]

$c - a = w$
$c =$ calculated butter yield
a $=$ actual butter in churn when first moisture test is taken
$w =$ water to add to bring to desired moisture

632 lb. fat to churn
Desired composition:
15.9 per cent moisture
2.8 per cent salt
0.8 per cent curd
80.5 per cent fat

$$\frac{\text{fat} + \text{salt} + \text{curd}}{100 - \text{per cent moisture present}} \times 100 = \text{pounds of unfinished butter in churn}$$

(*c*) $632 \times 1.25 = 790$ lb. butter expected

$$\frac{632 + (0.28 \times 790) + (0.008 \times 790)}{100 - 12.9} \times 100 \text{ or}$$

(*a*) $$\frac{632 + 22.12 + 6.32}{100 - 12.9} \times 100 = 758.2 \text{ lb. unfinished butter}$$

$(c - a = w)$

$790 - 758.2 = 31.8$ lb. of water to add to unfinished butter

The results obtained by five methods of calculation show some variation. The figures for the five methods, given in the order of their presentation, are as follows:

Method	O. R. Figure Used	Pounds of Water to Be Added
1. Wisconsin Dairy School	25.00%	23.7
2. Winkjer, Burns and Burke		
a. Salt added after first moisture test	24.22%	30.3
b. Salt added before first moisture test	24.22%	27.04
3. Hunziker	25.00%	27.88
4. Wilster	23.50%	27.90
5. Trout and Jensen	25.00%	31.80

The first method shows the greatest variation from a probable normal figure. It is by far the simplest method and is the one which probably has found the greatest application by churnmen. It is admittedly less accurate than the other methods. It assumes that a 25 per cent overrun will be obtained, which is incorrect. Also, the first moisture test is made on unfinished butter and resulting computations are too low. Figures will best clarify this point.

Regular calculation:

$$\frac{632 \text{ lb. fat} \times 1.25(15.9 - 12.9)}{100} = 23.7 \text{ lb. water to be added}$$

Corrected calculation:

Unfinished butter, according to Wilster, 752.6 lb.

790 lb. finished butter − 752.6 = 37.4 lb. finished butter lacking at first moisture test

37.4 × 0.129 = 4.82 lb. of water not present but calculated as present when using the Wisconsin formula

Hence

23.7 lb. water + 4.82 lb. water = 28.52 lb., or correct amount of water to add to the churn

If the simpler formula is used, better results will be obtained if the salt is added and the butter worked 15 to 20 revolutions. Now add enough water to raise the moisture to about 15 per cent. Work an additional 25 revolutions. Now run the first moisture test and compute the amount of water to add to the churn to produce the desired finished composition.

Obviously the procedure outlined gives us butter which is more nearly finished before the first moisture test is made. It follows that the lack of moisture is less and that calculations therefore involve smaller numbers. Any imperfections in the method of calculation will produce less error.

A correction of the simple formula might be made, using a *Correction Factor* of *1.2*.

$$\frac{(1.25 \times \text{fat})\ (dm - m)}{100} \times 1.2 = \text{lb. of water to be added to churn}$$

Taking the problem involving 632 lb. of butterfat, we have results as follows:

23.7 lb. water by the original simple formula.

23.7 × 1.2 = 28.44 lb. of water when using the correction factor, 1.2.

Graphical Presentation. An attempt is made here to develop a method of graphical presentation of the problem of butter-moisture control. It is hoped that Fig. 83, accompanied by calculations, will

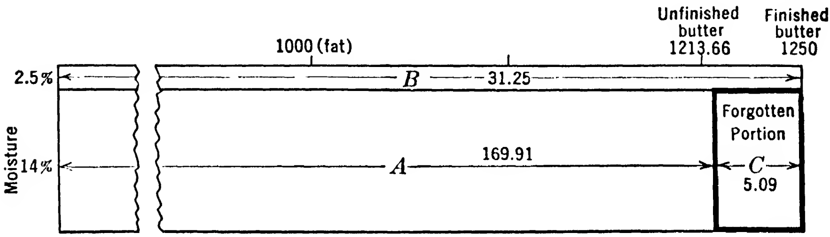


FIG. 83. Water calculation. Diagrammatical scheme—an aid in visualizing the procedure for calculating water to add to the churn to control the moisture content of butter. *A* represents the water in the unfinished butter ($1213.66 \times 0.14 = 169.91$ lb.). *B* represents the amount required to supply the increase of 2.5 per cent of the finished butter ($0.025 \times 1250 = 31.25$ lb.). *C* represents the usual "neglected portion" which is entirely overlooked by the Wisconsin formula and in the usual methods of the buttermaker (36.34 lb. $\times$ 0.14 = 5.09).

clarify the principles involved in the calculations of various authors given previously.

Problem:

1000 lb. fat: first moisture test, 14 per cent: assumed curd and salt content of finished butter, 1.0 per cent and 2.5 per cent respectively.

Desired composition: fat 80 per cent, moisture 16.5 per cent, salt 2.5 per cent, curd 1.0 per cent

1000 lb. fat $\times$ 1.25 = 1250 lb. butter expected

$0.01 \times 1250 = 12.5$ lb. curd and $0.025 \times 1250 = 31.25$ lb. salt

$12.5 + 31.25 + 1000 = 1043.75$ lb. of curd, salt, and fat

$100 - 14$ (first moisture) $= 86$

$1043.75 \div 0.86 = 1213.66$ lb. unfinished butter

$1250 - 1213.66 = 36.34$ lb. butter still to be made, or pounds of water to add to churn

The foregoing calculations are too complex for most buttermakers. The same problem, handled with the Wisconsin formula with a correction factor, is presented here.

Simple formula (Wisconsin)

$$\frac{(\text{Fat} \times 1.25)\ (dm - m)}{100} = \text{lb. water to add}$$

$$\frac{(1000 \times 1.25)\ (16.5 - 14.0)}{100} = 31.25 \text{ lb. water to add}$$

Correction factor suggested, $1\frac{1}{6}$

$31.25 \times 1\frac{1}{6} = 36.45$ lb. water to add to churn
$1250 - 36.45 = 1213.55$ lb. unfinished butter
$1213.55 \times 0.14 = 169.89$ lb. water
$1250 \times 0.025 = 31.25$ lb. water
$(1250 - 1213.55 = 36.45)$
$36.45 \times 0.14 = 5.10$ lb. water (forgotten portion)
Total 206.24 $(169.89 + 31.25 + 5.10 = 206.24)$

Check: $1250 \times 0.165 = 206.25$

It will be observed that a correction factor of $1\frac{1}{6}$ has been used above instead of 1.2 as suggested previously. Exact calculations as given below show the factor to be variable depending upon the amount of moisture in the first moisture test.

Source of Correction for Wisconsin Formula

First moisture test	(Fat, salt, curd) divided by (100—first moisture)	Pounds unfinished butter	Water required equivalent to pounds finished less unfinished butter	Water by Wisconsin formula	Ratio of required water to that figured by Wisconsin formula	Value of correction factor
13%	$\frac{1043.75}{0.87} =$	1199.7	50.29	43.75	$\frac{50.29 \text{ lb.}}{43.75 \text{ lb.}} =$	1.1494
14%	$\frac{1043.75}{0.86} =$	1213.66	36.34	31.25	$\frac{36.34}{31.25} =$	1.1628
15%	$\frac{1043.75}{0.85} =$	1227.94	22.06	18.75	$\frac{22.06}{18.75} =$	1.1765
16%	$\frac{1043.75}{0.84} =$	1242.56	7.44	6.25	$\frac{7.44}{6.25} =$	1.1904

Since the skillful operator is able to approach more closely the total pounds of finished butter before running the first moisture test, he may use the decimal factor 1.2 for easier calculation (avoiding fractions). Just as logically, however, it may be shown that the use of an additional one-sixth of the amount of water calculated by the simple formula is more exact, and particularly so since a 25 per cent overrun is presumed by the simple formula, and in reality is not obtainable with correct weights and tests. It is neither possible nor advisable to attempt to approach too closely an 80 per cent butterfat minimum.

An additional interesting approach to the problem of the usual "forgotten portion" is to consider the difference between the finished and unfinished butter (36.34 pounds) as a separate problem. The unfinished butter may have 2.5 per cent of water added and worked in ($0.025 \times 1213.66 = 30.34$). This will replace 30.34 pounds of fat, salt, and curd, which will leave the 1213.66 pounds of unfinished butter and pass to the new unit, 36.34 pounds. There will be required (0.165×36.34) or 6.0 pounds of water for the new unit. Therefore $30.34 + 6.0 = 36.34$ pounds, or the complete new unit.

36.34 × 0.80 fat	=	29.070	
36.34 × 0.010 curd	=	0.363	
36.34 × 0.025 salt	=	0.908	
		30.341	(coming from unfinished butter)
36.34 × 0.025 moisture	=	.908	(provided by Wisconsin formula)
36.34 × 0.14 moisture	=	5.100	(the usual neglected portion)
Total new unit	=	36.349	lb.

It must be stated here that success in moisture and composition control is not an exact procedure. Even though careful calculations of the water to add to the churn are made, much still depends on the skill of the buttermaker. *He must drain the wash water thoroughly*, and he must decide by experience the probable rate of moisture incorporation. Excessive working, merely to incorporate moisture, must be avoided. Injury to the texture of butter may result and a possible lower market price may more than offset gains from a slight increase in the number of pounds of butter.

Moisture control in butter was not known until about 1907. Overrun varied greatly, and butter contained 12 to 15 per cent of moisture. The fat content of butter was frequently as high as 85 per cent, at times falling below 80 per cent. In control work in Iowa, within the past 5 or 6 years, Professor Mortensen has found appreciable variations in butter composition. He, cleverly, suggests that such conditions indicate that the creamery is running itself. (See Fig. 84.)

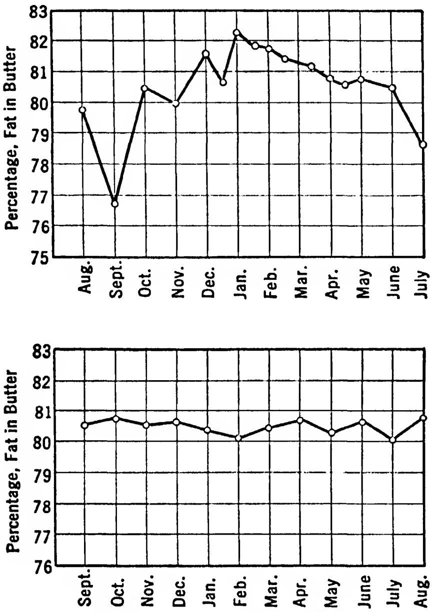


FIG. 84. Butter composition control. Creamery A (top) represents the work of an unskilled operator; quoting Mortensen, *"This creamery runs itself."* Creamery B (bottom) shows excellent control; quoting Mortensen, *"There is a butter maker in this creamery."*

In 1909, Lee, Hepburn, and Barnhart [17] showed that wet salting seems preferable. They indicated that a method practiced for two years prior to 1909 was giving good results in the creamery at the University of Illinois. That method included draining the wash water thoroughly from the churn and adding both salt and water to the churn in calculated amounts. The old method of not draining carefully in order to leave some wash water in the churn to facilitate salt solution was condemned.

Mortensen [18] in 1932 showed the wide variation in the composition of butter in two Iowa creameries. (See Fig. 84.)

Economics of Moisture Control. The graphs tell the whole story, but we will show the money involved in two creameries making 500,000 lb. of butter annually. Creamery A makes butter with 82.5 per cent of fat. Creamery B makes butter with 80.5 per cent of fat.

Creamery	Average % fat in butter	Preventable loss % fat	Butter price lb.	Lb. fat lost	Value fat lost	Value butter lost
A	82.5	2	30¢	10,000	$3,000	$3750
B	80.5	0	....	....	....	....

NOTE: Value of butter computed. 10,000 lb. fat lost.
10,000 × 1.25 = 12,500 lb. butter.
12,500 × 30 = $3750.

The operator in creamery B saved $3750 per year in fat costs alone. If the butter was more uniform and marketed to better advantage, perhaps one-fourth cent per pound, we may add another $1250. This makes a total of $5000. The question arises, "What is the value of a buttermaker?" In addition, the graphs show that one creamery made butter of illegal composition about three months out of the year. Had this butter been seized by the federal government the amount of fines and reworking costs would have added considerably more to the total loss.

Amount of Working and Keeping Quality. There is no convincing evidence that the amount of working which butter usually receives has any appreciable effect on its keeping quality. Very seldom is butter worked so little that the moisture and salt are not sufficiently distributed to gain the benefits of the antiseptic action of salt. In butter which is admittedly overworked there is probability that its keeping quality is impaired. Sommer and Smit,[19] in studying fishy flavor in butter, list overworking as one of the factors which induce fishiness and indicate that the more complete incorporation of air exposes more of the ingredients of butter to oxygen. On the other hand Hunziker [20] and Prucha, Brannon, and Ruehe [21] have reviewed and studied the effects of adding carbon dioxide to butter and other dairy products. They indicate no improvement was noted and in some instances keeping quality was impaired. It appears, therefore, uncertain that slight overworking of butter, from the standpoint of more complete incorporation of air, is detrimental to keeping quality. Excessive working should be guarded against, however, from the standpoint of body and texture as well as the possibility of induced deterioration.

Overworking may accelerate the oxidation of lecithin and particularly so if either high acid or high salt are present. Both high acid and high salt are more certain to cause deterioration.

QUESTIONS

Washing

1. What are the objects of washing butter?
2. What is standard practice with respect to the temperature of wash water?
3. Explain unusual variations in wash-water temperature and give some reasons for such changes.
4. Give some reasons why butter might be worked in wash water.
5. Is wash water a possible source of sediment in butter? State remedies.
6. Explain the control of body and texture in butter through regulation of wash-water temperatures.
7. Why is butter now worked much more than formerly?

Salting

8. State reasons for salting butter.
9. Who uses unsalted butter? Why?
10. If butter is salted at a rate of 3 pounds to the hundred pounds of butterfat, what is the calculated percentage of salt in the finished product? What will probable percentage be? Why?
11. What methods of adding salt to butter are used? Why?
12. Why may butter from one end of the churn contain more salt?
13. How much salt will water at 58° F. dissolve? What percentage of salt will dissolve in the water in butter at 50° to 58° F.?
14. What are some of the common impurities in butter salt? Is their presence a serious obstacle in standard brands of salt?
15. What salt percentage would you suggest for storage butter? Why?

Working

16. State the purposes of working butter.
17. List some factors which determine the extent of working.
18. How is water expelled from butter containing less than 80 per cent of fat? Explain the diagrams:
19. What are the objections to overworking and underworking of butter?
20. List the causes of mottles in butter.
21. Why is unsalted butter never mottled?
22. Give a simple formula for use in adding water to work into butter. Why are formulas not entirely dependable?
23. Show with figures the savable financial loss to a creamery under the following conditions:

a. Annual output of butter, 700,000 lb.
b. Average butter composition, 83 per cent fat.
c. Average price of butterfat, 33 cents.
d. Average market price of butter, 33 cents.
e. Average percentage of fat desired in butter, 80.5.

Calculate (*a*) the value of butterfat unnecessarily included in the butter; (*b*) the value of this fat if made into butter with a 24 per cent overrun.

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CHAPTER 12

OVERRUN

Definition. Overrun constitutes the difference in weight of the finished butter and of the fat used to make that butter. It is expressed as the percentage of increase on the basis of fat used. This gain in weight is composed of water, salt, and curd. Aside from this increase on the basis of composition of the butter, there are numerous other factors which enter and which constitute largely, losses of fat between the amount paid for and that which actually is recovered in the finished butter.

Significance of Overrun. The gain in weight of the butter, over the amount of fat used to make it, is the main source of income for the creamery. If 100 pounds of fat yield 124 pounds of butter, the creamery has 24 pounds extra to sell. The 24 pounds, consisting of water, salt, and curd, cost the creamery nothing except the cost of salt (about 1.7 cents per pound). The sale of this extra 24 pounds yields gross profit in accordance with the market price of butter.

$$24 \text{ lb.} \times 20¢ = \$4.80$$
$$24 \text{ lb.} \times 50¢ = \$12.50$$

We see at once the interest of the creamery operator in higher butter prices.

One might imagine that, if it is possible to operate with 20-cent butter and make some net profit, a creamery would become fabulously rich if butter prices were to remain at higher levels. Although chances for success are better, they are not better in proportion to the price of butter. When butter is selling at 20 cents, the creamery is, in most instances, paying less than 20 cents per pound for butterfat. When butter sells for 50 cents, the creamery may be paying as much as 5 to 7 cents over butter prices for a pound of fat. Obviously, a large portion of what might appear to be profit is consumed in higher fat prices. Severe competitive conditions may at times jeopardize profits, even though butter sells for 50 cents per pound. A study of the figures below will clarify this point.

Pound Butter	Pound Fat	Pound O. R.		
124	100	24	24 @ 20¢ =	$ 4.80 gross profit
			124 @ 3.5¢ mfg. cost =	4.34 mfg. costs
				.46 net profit
124	100	24	24 @ 50¢ =	$12.50
			124 @ 3.5¢ mfg. cost =	4.34
				7.16 net profit

Now let us see what happens when we pay 2c less for fat with 20-cent butter. Also, we shall pay 5 cents over with 50-cent butter.

124	100	24	100 lb. fat @ 20¢ =	$20.00
			100 lb. fat @ 18¢ =	18.00
				2.00 saving
			$2.00 plus $0.46 (net profit at 20¢) ..	$2.46 net profit
124	100	24	100 lb. fat @ 55¢ =	$55.00
			100 lb. fat @ 50¢ =	50.00
				5.00 extra cost
			$7.16 − $5.00 =	$2.16 net profit

We see that more net profit results in this case when butter sells at 20 cents. Actually, the net profit would be less than $2.16 with the 50-cent butter. Naturally, most costs would be higher and manufacturing costs would be greater than 3.5 cents, thereby reducing the net profit.

The ability of a creamery operator to pay only a reasonable price for fat, to secure and maintain volume of cream and fat, and to so control manufacturing costs and sales of butter that profits are quite consistently maintained will determine his value to the creamery. Only experience and good judgment will so qualify a creamery manager.

Kinds of Overrun. We list several bases of figuring overrun:

1. Factory.
2. Churn.
3. Composition.

Factory Overrun. Factory overrun is that which is figured on the basis of total pounds of butter sold and the total of butterfat bought. It is broad and inclusive. It is reduced by several factors. All losses of butterfat in processing reduce factory overrun. All losses of butter also reduce factory overrun. Many creamery operators may be severely criticised for carelessness about butter losses. All sales of butter must be checked with morning and evening inventories. All butter from the churn should be promptly recorded. The manager should not leave the plant until all butter is accounted for. Butter going on cream routes must be accounted for and losses charged back to the driver. Inventory losses must be adjusted very promptly. Carelessness in handling charge accounts reflects gross discredit. If a patron receives butter and is not charged for it, he has reason to question the ability and integrity of the management. He might also be charged for butter he did not get. The butter-checking sheet on page 270 is offered as a guide.

Some adaptations of this general plan should make it applicable to several churnings, purchases, sales, etc.

Churn Overrun. A buttermaker may check his efficiency separately, by taking vat tests of cream, buttermilk fat tests, and calculating overrun from the churn by the gains figured on the difference between pounds of butter and pounds of fat determined. A buttermaker may be accused unjustly of lack of efficiency when he is charged with the pounds of fat as determined by the intake man.

Composition Overrun. In this determination, a complete analysis of butter is made. The percentage of non-fat ingredients divided by the percentage of fat in the butter equals the overrun.

Figures demonstrating the three kinds of overrun are:

(O.R. = overrun)

1. *Factory overrun:*

322,580 lb. fat recorded in intake (annual)

400,000 lb. butter made

400,000 — 322,580 = 77,420 lb. O.R. (actual)

77,420 ÷ 322,580 = 24% O. R.

399,200 is total lb. butter accounted for in sales and inventory. Hence 800 lb. of butter is lost.

399,200 — 322,580 = 76,620 lb. O.R. (accounted for)

76,620 ÷ 322,580 = 23.75% O.R.

BUTTER INVENTORY RECORD

Pounds fat churned..............% O. R............... Date.

	Tubs	Fridays	Prints	Jars	Scraps	Total
Inventory, A.M.........						
Churned.............						
Bought..............						
Returned.............						
Transferred (in).......						
Gains................						
Total................						
Sold.................						
Transferred (out)......						
Losses...............						
Inventory P.M.........						
Total................						

2. *Churn overrun:*

Presume a churning of 1000 lb. of butter.

820 lb. fat recorded at intake

$1000 - 820 = 180$ lb. gain

$180 \div 820 = 21.9\%$ O. R.

806.4 lb. fat according to vat test

$1000 - 806.4 = 193.6$ lb. gain

$193.6 \div 806.4 = 24\%$ O.R.

21.9% O.R. is recorded, based on fat records at intake; obviously unfair to an efficient churn man.

3. *Composition overrun:*

Analysis of butter,

Moisture	16.5%
Salt	2.0%
Curd	0.8%
	19.3%
Fat (100-19.3)	80.7
Total	100.0

19.3 ÷ 80.7 = 23.91% O.R.

Winkjer, Burns, and Burke [1] cite these possible fat losses:

POSSIBLE LOSSES OF BUTTER IN RECEIVING AND PROCESSING 500 POUNDS OF BUTTERFAT IN CREAM FROM 100 PATRONS

Source of loss of butterfat	Loss of butterfat in terms of butter		
	Normal losses	Frequent losses	Extreme losses
	Pounds	Pounds	Pounds
Farmers' cream cans	0.00	0.50	1.00
Weigh can	.06	.50	1.00
Sample jars	.05	1.65	2.00
Test bottles	.70	.70	.70
Spilling cream in taking samples	.03	.50	1.00
Vat strainer	.18	1.00	2.00
Coils and sides of vat	.50	1.00	2.00
Rinsings in vat	.16	1.82	3.00
Pumps and pipes	.03	.33	1.00
Churn strainer	.05	1.00	2.00
Leaks in machinery	.04	.75	2.00
Fat in buttermilk	5.30	8.00	11.00
Butter sticking to inside of churn	.30	3.00	13.00
Butter sticking to ceiling overhead	0.00	.10	.20
Boxes and tubs	.04	.62	1.00
Printing machine	.03	.50	.62
Wrapping	.02	.50	.75
Scraps	.01	.25	.43
Total	7.50	22.72	44.70
Possible overrun	23.50*	20.456*	16.06*

* Percentage by weight that the quantity of butter produced exceeds the quantity of butterfat in the cream.

Need of a Good Manager. Some of the losses are avoidable; others can be greatly reduced by a careful operator. In fact, a reduction in overrun from 23.5 per cent to 20.45 per cent by a careless operator would be reason enough to replace him with an efficient man. Winkjer, Burns, and Burke indicate the decline from 23.5 per cent overrun to 20.45 per cent, as from normal losses to frequent losses. This prompts the belief that a careful butter-maker and some new equipment may be good investments in some creameries.

Frequent and extreme losses occur. They depend somewhat on the equipment and methods used in a creamery. The major factor is the efficiency of the operator.

Let us consider a creamery making 500,000 pounds of butter per year. The difference between 23.5 per cent overrun "normal losses" and 20.45 per cent overrun "frequent losses" represents 13,382 pounds of butter. This amount at 30 cents per pound represents $4,014.60. This furnishes additional proof of the need of an efficient operator.

500,000 of butter = 123.5% of the butterfat
500,000 ÷ 123.5 = 4,040 or 1%
4,040 × 100 = 404,000, or the butterfat bought in a year
404,000 × 1.2045 = 486,618, or the total pounds of butter made with a 20.4% O.R.
500,000 — 486,618 = 13,382 lb. of butter short
13,382 × 30 cents = $4,014.60 annual loss

Checking Overrun Troubles. Difficulty with overrun must be corrected by checking the following considerations:

1. Intake scales.
2. Manner of sampling cream.
3. Cream test scales and weights.
4. Manner of reading cream tests.
5. General mechanical losses and wastes indicated by U.S.D.A. Circular 294 (see table on p. 271).
6. Test scales and weights used for butter analysis.
7. Method of taking butter sample for analysis.
8. Technique of butter analysis.
9. Strength of silver nitrate solution.
10. Scales for weighing butter from churn.
11. Buttermilk fat losses.

The detail of checking scales and weights, as well as the technique of testing, and the chemicals used in the tests, must be left to the laboratory. All scales should be checked periodically by a competent inspector. Cream-test scales and butter analysis scales needing repair should be returned to the manufacturer or other authorized agency. If chemical solutions are in question, buy new solutions.

Weighing Cream and Reading Cream Tests. Figures previously given regarding the amount of cream and fat recorded in the intake show the importance of correct weights and tests as they affect creamery overrun.

The question frequently arises as to what to do about half-pound weights of cream and half-point differences in tests. Should the weight be recorded as 80.5 pounds and the test as 32.5 per cent? Considerations bearing on this point are:

1. Fairness and justice to the farmer.
2. Overrun—creamery cannot justifiably pay for more than it gets.
3. Mistakes in calculations and records due to the use of fractions.
4. Empty cream-can weights; they vary and do not weigh even pounds.
5. The creamery adds a few ounces of butter to each tub for shrinkage. Central markets pay for full pounds only, not fractions.
6. Duplicate tests of cream frequently are not read alike.
7. State inspectors usually allow a tolerance of about 1 per cent in making tests.
8. Some fat is unavoidably lost in test samples and in the buttermilk.

A survey of six or eight north central states to learn their attitude on the matter of recording half-points in weights and tests showed that most of them did not require such records. Their opinion was that mistakes in calculations and records would result, and that correct sampling and proper technique in making tests was of greater importance.

No one denies the point of justice to the farmer. Likewise, no one denies the justice to the creamery operator. He must produce full weight when he sells and does not get paid for fractions. Pound prints of butter must slightly exceed 16 ounces in order to allow for some shrinkage.

A price differential in payment for grades of cream is of greater importance to the producer than the recording of half-points in weights and tests.

Sampling Cream. Care in taking a representative sample of cream for testing is very essential. It is the first requisite to correct testing. Cream arriving at the plant may be rich, cold, and viscous, and may require much stirring. It may be low in fat and much thinner at the bottom of the can, owing to fat rising. Ample stirring is needed before a uniform sample is obtainable. Partially frozen cream must be thawed before sampling. Water freezes out first, and the unfrozen portion is richer. Stirring rods are usually used as samplers. Small dippers also are used. Either of these instruments should be rinsed with water in passing from one can to another in order to avoid transferring rich cream to thinner cream, and vice versa. If unused for intervals, they should be immersed in a can of water to prevent attraction of flies.

When more than one can of cream is received from a single patron, a weigh can is very useful. It is very difficult, if not impossible, to get one representative sample from several cans of cream, several of which probably will not be full. When the entire lot is dumped in a weigh can, proper sampling is much easier.

The McKay sampler (see cut, Chapter 19) has been used and is a great help in individual can sampling. This consists of two telescoping metal tubes, slotted on one side. When the sampler is inserted in the cream, the slots are open. A half-turn of one tube closes the openings, and a tubeful of cream is drawn for the sample bottle. Lack of stirring before sampling and partially filled cans do not present difficulty.

Composite Cream Samples. Some creamerymen, particularly in farmers' creameries, take composite samples. Daily samples added to composite samples must be obtained in amounts proportionate to the volume of cream in the daily delivery. Failure to do this may result in the addition of an unduly large amount of cream of a different test. Obviously, the composite sample would not be representative. Contention that some daily samples are richer and others are thinner and that an equalization would take place over a period is unsound. Correct sampling is too important a consideration. For care and testing of composite samples, see Chapter 19, "Testing."

Overrun Calculations in Creameries Receiving Whole Milk. Overrun in creameries where whole milk is received is usually appreciably less than overrun obtained where only cream is bought. The greater the bulk of product handled, the greater is the chance that more handling losses occur. Milk plants under average operating conditions may lose 1 to 3 per cent of the total pounds of milk bought. Failure to drain cans may account for one-fourth to one-half pound per can. Leaks in pipes, carelessness in draining vats, pipe lines, and pumps, etc., are causes of additional losses.

Cream separators do not remove all the fat from milk. If large quantities of milk pass through one separator, its efficiency is gradually reduced because of accumulation of "separator slime." The bowl actually has less capacity when partially filled with slime, the milk does not remain in the bowl so long and is not subjected to centrifugal force long enough to cause proper separation of fat from serum (skim), and more fat is lost in the skim milk. It is sound practice to stop a separator for cleaning after 1½ to 2 hours of skimming.

Figures indicating probable overrun when separated cream is made into butter are as follows:

Pounds milk received, 30,000; test 3%
Pounds fat paid for, $0.03 \times 30{,}000 = 900$
Pounds butter possible, $900 \times 1.24 = 1116$
Suppose 0.02% fat lost in skim
Separating ratio, 10 lb. cream to 90 lb. skim
$10 : 100 = x : 30{,}000$
$x = 3000$ lb. cream
$30{,}000 - 3000 = 27{,}000$ lb. skim
0.0002 (0.02%) $\times 27{,}000 = 5.4$ lb. fat
$5.4 \times 1.24 = 6.7$ lb. butter equivalent

$1116 - 6.7 = 1109.3$ lb. butter (5.4×1.24 lost in skim)
$1109.3 - 900 = 209.3$ lb. O.R.
$209.3 \div 900 = 23.2\%$ O.R.
24% O.R. $- 23.2\%$ O.R. $= 0.8\%$ lost because of skim-milk fat losses
Presume 2 per cent mechanical losses of whole milk
$30{,}000 \times 0.02 = 600$ lb. milk
600 lb. $\times 0.03 = 18$ lb. fat lost
$18 \times 1.24 = 22.3$ lb. butter equivalent
$1116 - (6.7 + 22.3) = 1087$ lb. butter actually made
$$\frac{1087 - 900}{900} \times 100 = 20.77\% \text{ O.R.*}$$

Buttermilk fat losses and mechanical losses in churning are not considered here as special problems. Such losses would be incurred in any churning operation.

The extra fat losses sustained in whole-milk plants indicate that churning should be the last resort in the use of the fat. There are more profitable outlets, such as marketing sweet cream, ice-cream mixes, etc. There must also be a profitable use of the skim milk, such as cottage cheese, milk powder, casein, etc.

Many modern plants are buying whole milk now where formerly they bought cream. These plants are equipped to make all dairy products, and the milk is utilized in the most economical manner. As further indication that the manufacture of butter is less profitable and is practiced as a last resort, let us cite the use of stored sweet cream for butter when the market for sweet cream is glutted.

QUESTIONS

1. What is meant by the term "overrun" in buttermaking?
2. State the relation of overrun to creamery profits.
3. List and explain three methods of calculating overrun.
4. If butter composition overrun shows 24 per cent and factory overrun shows 22 per cent, what may be causes of the difference?

* Dahlberg found 0.6 per cent of fat and 0.5 per cent of milk lost in 8 well-managed New York plants receiving an average of 62,442 pounds of milk daily. (Farm Research, Apr., 1939, Geneva, N. Y.) Obviously extra losses would be incurred by separation (skimmilk fat losses) and by churning the cream (buttermilk fat losses).

5. Explain the importance of daily inventories of butter from the standpoints of:
   a. Business ethics.
   b. Factory overrun.
6. Make a list of factors to be investigated if you were to determine the cause or causes of low overrun in a creamery.
7. List the points for and against the recording of half points in weights and tests of cream.

REFERENCES

1. WINKJER, J. G., W. F. BURNS, and A. D. BURKE, "Practical Pointers on Making Creamery Butter in the South," U. S. D. A. Cir. 294, 1933.

CHAPTER 13

DEFECTS IN BUTTER: THEIR CAUSES AND PREVENTION

FLAVOR DEFECTS

A number of common defects in butter are listed as follows on the score card used by the United States Department of Agriculture, Bureau of Dairying, for students' judging contests. It was originally prepared and adopted by the American Dairy Science Association.

Acidy. Acidy butter is made from unneutralized cream which has an acidity of 0.25 per cent, or more, or it is made from butter which has been ripened too high with starter. It has a slight sharpness of flavor which tends to coarseness and indicates poor keeping quality.

Bitter. Cream which has bitter fermentation is frequently found in the fall and winter, when farm production is low and the cream is held too long on the farm. Although it has been kept too cold to sour, it may develop bitter flavors which are carried into the butter.

Bitter flavor may be caused by weeds, particularly in the fall of the year. Too much neutralizer or its improper application may be a cause. Impure neutralizers may be a factor. Certain types of bacteria thrive in cold sweet cream if held too long and produce bitterness. Lipolysis of fat may also cause a bitter flavor, particularly if milk and cream contain abnormal amounts of lipase.

Briny, Coarse. These flavor defects are frequently found together. The cause is either high salt or insufficient working, or both. The droplets of brine are large enough to give to the butter an excessively salty taste. Sometimes butter that is unpleasant in flavor, and to which no definite flavor defect can be assigned, is designated as coarse.

B.D.I.33

BUTTER SCORE CARD

For Students' National Contest in Judging Dairy Products

Contestant No. . . . . Sample No. . . . .

	Student	Official	Grades: Score	Grades: Criticism
Flavor (45)	. . . .	. . . .	. . . .	. . . .
Body (25)	. . . .	. . . .	. . . .	. . . .
Color (15)	. . . .	. . . .	. . . .	. . . .
Salt (10)	. . . .	. . . .	. . . .	. . . .
Package (5)	. . . .	. . . .	. . . .	. . . .
Total (100)	. . . .	. . . .	. . . .	. . . .
Placing	. . . .	. . . .	. . . .	
Grade on criticism			. . . .	
Total Grade			. . . .	

Criticisms

Flavor

Acidy	Cowy	Metallic	Storage
Bitter	Feed	Musty	Tallowy
Briny	Fishy	Neutralizer	Unclean
Burnt	Flat	Oily	Weedy
Cheesy	Garlic	Old Cream	Woody
Coarse	Gasoline	Rancid	Yeasty
Cooked	Heated		

Body

Cloudy brine	Greasy	Mealy	Weak
Crumbly	Leaky	Salvy	

Color

Color specks	Mottled	Uneven
White specks	Wavy	

Salt

Gritty

Package

Dirty tub Poor finish

Burnt, Cooked, Heated. There is no great differentiation in these three terms. They all refer to excessive heat in pasteurizing cream, which may come from uncontrolled flash pasteurizers, from vat pasteurization when the vat is less than two-thirds full and the coils cook the cream, or from heating high and holding too long by any method of pasteurization. Such flavors in butter may be very prominent for a week or two and then disappear entirely. Only severe treatment of the cream will produce relative permanency of such flavors.

Cowy. This flavor is not common. It may be encountered when cows are kept in foul and unventilated barns. Usually such conditions are accompanied by careless milkers and attendants. The milk may sit uncovered in the barn for some time. It may be separated in the odors of the barn, and absorption of odors is easy. Cans stored in the barn will readily hold such odors.

Feed. Feed flavors have already been discussed under "Buying Cream," in Chapter 6 (p. 84). Strong feeds must be given *after* milking to help overcome this difficulty. This permits a period of 10 hours or more under barn-feeding conditions for the cow's digestion and metabolism to eliminate partially the odors and flavors from her system. The milk will thus be less likely to be badly affected. Pasture conditions present greater difficulties. The cows should be brought in 2 to 4 hours before milking.

Weedy Flavors. Weedy flavors are usually found in summer butter. In the early summer, French weed, also known as stinkweed, may be very troublesome. Peppergrass, as found in such abundance during the 1935 season in several extended areas in the Northwest, presented serious difficulty. Dry seasons, which encourage the development of these weeds when grass is scarce, make rather insurmountable trouble.

Butter thus flavored sells at greatly reduced prices (see footnote).* An interesting angle to the peppergrass-flavored butter of

* Some recent unpublished work at the South Dakota Experiment Station indicates that green French weed produces offensive flavors and odors in milk, cream, and butter. Such flavors persisted for 3 months in butter stored at 0° F. Cows required starving for 48 hours or more before they ate limited quantities. Green peppergrass was readily consumed by cows. With a ration of peppergrass only, milk, cream, and butter had objectionable grassy or weedy flavors. This butter was considered marketable whereas the butter from cows on the French-weed ration was considered definitely unsalable.

1935 was related by Mr. P. C. Betts of the Dairy and Poultry Cooperatives, Inc., Chicago. A few buyers who used this peppergrass butter at greatly reduced prices became accustomed to its high flavor and still called for it after all such butter had been sold from storage. They were willing to pay just as much for it as for high-grade butter. Old cream and fruity-flavored butter sometimes sells at unjustifiable prices when it goes to certain retail outlets. Mexicans, Italians, Spaniards, and other peoples who like high-flavored foods readily accept high-flavored butter in preference to mild sweet-cream butter.

Oily, Metallic, Tallowy, Fishy. These four flavors are considered simultaneously because they frequently represent a sequence of flavor development. Butter may be oily and not develop any of the other related flavors. Oiliness may come from high heat and lack of agitation in pasteurizing. Cream may have an oily flavor, which carries to the butter.

Metallic flavor usually comes from dissolved metals in the cream. Producer's cans may be rusty. Cream vats may be poorly tinned, exposing bare copper, and thermometer bulbs may be bare copper. In rare instances, this flavor defect may come from bacterial action, as shown by Guthrie [1] in 1916. He stated that either good or bad cream may produce butter with this defect.

Tracy, Ramsey, and Ruehe [2] in 1933 studied tallowy flavor in milk and cream, concluding that bacteria and yeasts play a part in the control of tallowy flavor. Low-count milk produced in the winter frequently develops a tallowy flavor when held after pasteurizing and bottling. Summer milk, sold as market milk, seldom has this flavor. Tracy, Ramsey, and Ruehe believe bacterial activity in milk, before delivery to the plant, acts as an inhibitor to this flavor. They experienced tallowiness in butter at the University creamery when good cream was held three days at 40° F. before churning. Holding such cream in glass vats for the same period and at room temperature greatly reduced the frequency of tallowy flavor in butter.

More recently Sharp, Trout, and Guthrie [3] have indicated that tallowy or oxidized flavor in milk is associated with a reduction of the ascorbic acid (vitamin C) content of milk. Pasteurization at 170° F. for 10 minutes very largely inactivated an enzyme which oxidizes ascorbic acid and in most instances prevented the development of the tallowy flavor. Pasteurization at 145° F. for 30 minutes was also quite effective in preventing tallowy flavor if every precaution was taken against solution of copper in the milk.

A. M. Swanson and H. H. Sommer (Wis. Bull. 442, 1938, Part I of Annual Report of Director of the Experiment Station) report that lecithin and cephalin, and not the true butterfat portion of milk, may be responsible for oxidized flavor. Preliminary trials are reported. The presence of dissolved metals was indicated as a contributing factor.

Metals in cream, particularly copper, are a cause of tallowy flavor. A strip of copper inserted into a pound print of butter will produce typical color fading and an old tallow taste.

Exposure of pound prints of butter to direct sunlight will produce a similar defect, which in this case travels from the surface toward the center as it develops. It is possible that metals induce tallowiness, and that limited bacterial activities help retard such flavor development.

Fishy flavor has already been discussed in Chapter 11, p. 235 and Chapter 9, p. 186. Butter from raw cream of medium to doubtful quality often becomes fishy when stored a few months. Efficient pasteurization eliminates this consideration as one of the factors. However, some butter is made from raw cream during the flush season. Lecithin is the source of fishy flavor. It is changed by chemical reaction to trimethylamine, which is the fishy-flavored substance. The factors which favor the development of fishy flavor in butter are listed by Sommer and Smit [4] as follows:

1. Presence of iron and copper salts.
2. High acid in the cream.
3. High salt in butter.
4. Overworking.

Raw cream, also a factor, is much less frequently encountered.

Flat. Sweet-cream butter, and especially with low salt content and made during the fall and winter, may be decidedly lacking in flavor. Neutralized, unripened, low-salted butter may also be described as flat or lacking in flavor. Excessive washing, or allowing the butter to remain in the wash water for long periods, may tend to produce butter which lacks flavor.

Garlic or Onion. These flavors come from cream produced by cows' eating these weeds in the pasture. The butter so tainted has very low marketability. Prolonged vacuum treatment of hot cream very largely removes such flavors, but the small creamery is not equipped with this expensive machinery. Recourse is had to grading very carefully. Do not accept such cream, or save it and run onion-cream churnings. The buttermaker will soon discover the need of deodorizing the vat and churn after handling such cream. The producer should be warned to avoid the use of pastures containing such weeds.

Gasoline and Kerosene. The prevention of such flavors in butter is obvious. Inexperienced men in the intake are a liability to be avoided.

Neutralizer. The improper application or excessive use of neutralizers, especially on high-acid cream, is the cause of this flavor. High-temperature pasteurization increases its intensity. Neutralization must be considered a task of major importance. It must not be hurried. Rushing neutralization and pasteurization is a frequent cause of neutralizer flavor. Exact figures and the application of both the science and art of neutralization are imperative.

Old, Stale Cream. These are very common criticisms of butter flavor. To overcome this trouble the operator must continually help his patron. He must grade cream conscientiously and pay a lower price for poor cream.

Rancid. Butter from good cream seldom becomes rancid if refrigerated properly. Cream may be rancid and the butter may have a rancid flavor even under good storage conditions. Rancidity results from the breaking down of fat into free fatty acids. Butyric acid produces a typical rancid odor and flavor.

Yeasty. Yeasty cream produces butter with this flavor defect. Unclean conditions on the farm and summer temperatures are responsible for yeasty cream. The unwashed cream separator again comes in for severe criticism. Yeasty butter will not keep well in storage and always has a sales disadvantage. Yeasty cream is recognized easily when it causes cream to foam. When the lid is removed from a can, yeasty cream is readily recognized by the same odors which accompany yeast-activated bread dough.

Surface Flavor (Putrid or Limburger). Butter stored for short periods may develop some degree of off-flavor at its surface, which may be due to one or several factors. The change which occurs at the surface may be due to chemical or microbiological processes, or may be due to mere absorption of odors from the container or from the air of the storage room.

Associated with surface flavors, but undoubtedly of different origin, are the so-called putrid or Limburger flavors, when the whole mass of butter contains a foul odor and taste. This condition is not common, and its causes are not fully understood. In Canada an outbreak of this trouble was traced to impure water used in the creameries. These flavors may also be associated with, or follow, the development of cheesy flavor in butter. Excessive curd in butter from low-grade cream which has been overneutralized may contribute to protein decomposition, with later putrid-flavor development. Relatively high storage temperatures will hasten decomposition.

Surface flavor in butter is a very serious defect. Consumers will use butter containing undesirable flavors and not be aware of their presence. No consumer, however, fails to recognize foul putrid odors on butter, and it is usually returned to the merchant. It is unlikely that over 50 pounds out of 1000 would be retained by the consumer. The reputation of an established brand of butter may be ruined promptly if such butter is sold.

The use of the removable workers in Simplex churns was discontinued because of difficulty in sterilization. It is quite possible that they were responsible for some flavor defects in butter.

Surface flavor in butter may occur when sweet cream is churned. The presence of acid in sour cream or in ripened cream butter has an inhibitory effect on organisms which cause putrid odors and flavors.

To guard against surface and putrid flavors:

1. Keep all equipment in a sanitary condition.
2. Grade cream carefully upon receipt.
3. Avoid overneutralization.
4. Pasteurize thoroughly and carefully.
5. Check the purity of wash water for butter (overhead tanks should be clean and sanitary at all times).

Sweet Curdling of Cream. Of interest, but not known to be related to surface or putrid flavor, is the occasional sweet curdling of cream. Abbott [5] in California describes trouble in handling sweet cream which he attributes to peptonizing bacteria. Where the sweet cream is pasteurized it may contain small curd particles. Instances have been reported where about one-third of the cream in the lower part of the vat contained curd. Such instances are not common. Occasional appearances of this condition usually coincide with periods of unusually wet weather, when cows wade in muddy pools, or in hot weather, when they may stand in stale pools and fight flies. No plant-processing methods have been developed to overcome this sweet curdling. Such trouble is usually remedied by careful attention to cows, and utensils used on the farm.

While butter flavor and quality may not be lowered by the presence of peptonizing bacteria, nevertheless efforts to avoid them are necessary because of increased losses of butterfat during churning.

Ropy Milk and Cream. Of further interest in connection with a discussion of sources of bacteria which may cause putrid flavors in butter and those causing peptonization in cream is the fact that organisms which cause ropiness in milk and cream may come from similar sources. These organisms are not difficult to destroy, but careless plant methods may cause considerable contamination of equipment, floors, walls, etc., and only persistent effort will eliminate the trouble. Careful checks for sanitation must be made both in the plant and at the source of production of the milk and cream. These organisms are not known to be unhealthful but are to be guarded against on the general premise of sanitation.

Microflora of Different Regions. A discussion of these unusual fermentations suggests the fact that different regions of the same country, and different countries, may have microflora which differ greatly. The general problem of sanitation remains the same, but different methods of control and varied processing procedures may be necessary. The fact that several hundred varieties of cheese are produced throughout the world and that certain varieties can be produced only in certain regions indicates the presence of certain types of organisms capable of producing typical fermentations.

Cheesy Flavor. Cheesy flavors may develop in cream and may be found in butter, even though the cream was not cheesy. Herried, Macy, and Combs[6] studied cheeselike flavors in unsalted butter. They found mixed organisms rather than single species were more frequently responsible for such flavors.

They found temperatures of 41° to 50° F. favored the development of cheesy flavors. They suggest that insanitary conditions at the farm and in the factory may be a source of trouble. Water, both at the farm and the creamery, may be a cause. Thorough sanitary measures in the creamery, efficient pasteurization of cream, particular attention to the churn, and careful cream grading may remove the causes. Storage of butter at low temperatures is effective in delaying such flavor development.

BODY AND TEXTURE DEFECTS

Leaky. Formerly leakiness was a rather common defect. It is due to insufficient working. Firm butter will incorporate water very thoroughly without injury to the body. A careless or inefficient operator may make leaky butter when working butter with firm body. This is quite inexcusable. When butter is soft at the time of working, the operator may not be able to incorporate the water properly without producing butter of greasy body. In an attempt to pursue a midway course, he produces leaky butter. Keep the butter firm at working time and work it until it shows no free droplets when the surface is scraped, or until a mass of the butter expels no water when pressed firmly. Adding wash water too late in the working process may be a cause of leakiness.

Mealy and Crumbly. These defects are noticeable when butter is spread on bread. The butter judge readily detects this fault. Butter is frequently short grained in the fall and winter, owing to small fat globules and to more hard fats in the butterfat. Warmer wash water has been the usual remedy. Recently the Minnesota station has shown that slightly higher churning temperatures and low wash-water temperatures are material aids. See Chapter 11 "Washing, Salting, and Working of Butter."

We might list the causes of mealy, crumbly butter as follows:

1. Small fat globules.
2. Higher percentage of hard fats.
3. Melting scrap butter with cream.

4. Insufficient or neglected agitation of cream during pasteurization.
5. Frozen cream.
6. Use of lime as a neutralizer, particularly if improperly applied.

It is not advisable to melt too much butter with the cream in the vat during pasteurization. This is a rather common practice in disposing of printing scraps. Some creameries with retail trade have found a ready market for this butter at a reduction of 1 or 2 cents in price. Such trimmings, when of uniform color, may be allowed to soften and then be packed into jars for local sale.

Insufficient or neglected agitation of hot cream may permit some oiling off and such a condition contributes to mealy body.

Frozen cream sometimes presents a problem. Either route cream or individual deliveries of cream may be partially frozen. Freezing partly destroys the smooth natural emulsion of cream. The casein is aggregated when the water of the cream freezes. When the cream is melted, the casein remains as small lumps of curd, and may be incorporated into butter, inducing mealiness. The effects of freezing fat-globule hulls also may alter normal butter body. The extent of mealiness in the butter may be considerably reduced by slow thawing of the cream. It is best thawed at room temperature. If working conditions require faster thawing, the cans may be set in water at about 80° to 90° F. It must be remembered that the faster the thawing, the more pronounced will be the mealiness in the butter.

Lime when applied too rapidly or in too concentrated mixture may cause a partial aggregation of casein. During the winter, when conditions favor crumbly butter, lime should be used with proper judgment in order to minimize or avoid an astringent effect on the proteins in cream.

Sticky Butter. Overworking of firm butter will incorporate the water in such tiny droplets that the butter lacks spreading ability. It sticks to the knife. It will not cut well with the wire cutters used in hotels and restaurants. It sticks to the trier when bored. A plug is removed with difficulty and the fat sticks to the trier and may roll. Some larger water droplets will produce some lubrication to the trier or the knife and stickiness is greatly reduced.

COLOR DEFECTS

Mottles or waves in butter constitute the major color defect. This has already been discussed under "working" in Chapter 11, p. 251. Different shades of butter in tubs may result from packing butter from both ends of the churn in the same tub. This condition seldom develops if the operator is efficient. If half-filled tubs from one churning are filled from the next churning, there may be butter of two colors. If this practice is followed, such tubs should be marked with two churning numbers or in such other manner as to inform the buyer.

Trimmings or scraps should not be worked in the churn with a churning of fresh butter. It is difficult to adjust the temperature of this butter to that of the butter in the churn. Uneven working results, and the butter may have yellow or light patches. This practice has the added disadvantage of introducing stale flavors. Professor Mortensen points out the possibility of having some butter passing in this way from one churning to another for months. This same possibility exists when scraps are melted with the cream in the vat.

White, Green, Yellow, and Rust Spots in Butter. White specks may be caused by casein particles passing through strainers and being subsequently incorporated in the butter. Special care must be exercised when frozen cream is processed. Strainers should not be allowed to clog and run over. Cylindrical strainers in the cream line to the churn are highly desirable.

Green spots may be caused by particles of copper or brass. These may come from the use of brass metal sponges on vat coils, from brass-fitted pumps or other surfaces which wear to the extent of giving off particles of the metal. The manner of prevention is obvious.

Rust spots or brown spots may be developed by tiny particles of iron in the butter. These may come from the use of steel wool on vat coils, from scraping metal surfaces, as in an iron pump, from rusty bolt heads and castings in churns, etc.

Yellow specks may be caused by using old butter color which has settled because of age or being stored at low temperatures. Larger yellow spots may be caused by packing small fragments of very soft butter such as may adhere to paddles, malls, etc.

SALT DEFECTS

Gritty butter is a result of using too much salt in proportion to the water which is incorporated in butter. Water at 58° F. will dissolve about 36 per cent of salt. When the water is incorporated in butter in fine droplets it will dissolve from 15 to 20 per cent of salt, depending on the purity of the salt, the manner and amount of working, the percentage of water in the butter, and the manner of salting. Work by the senior authors at the Iowa Station gave the results recorded below. The butter was worked at intervals during a period of an hour and salt was added in various amounts until a gritty condition resulted. The amount of salt that could be added without producing grittiness is given here.

In discussing defects of butter, remedies have not been given. To know the causes is sufficient. The intelligent operator will proceed to remove the causes when trouble is encountered.

Per cent moisture in butter	Per cent salt concentration in water in butter	Per cent salt in butter
16 92	16.57	2.7
11.58	14.09	2.0

With wet salting it is believed that 3.0 per cent of salt can be incorporated in complete solution in butter, if the moisture content is about 16 per cent.

QUESTIONS

1. Reproduce the score card for butter and list the major or more common defects of butter.
2. What are some causes of acidy butter? Of neutralizer flavor?
3. Name and describe some of the more intense flavors in butter made from cream which has been improperly cared for and has been held too long before delivery to the creamery.
4. How would you advise a patron who delivers cream with strong feed and weed flavors?
5. Why do we discuss the following flavors collectively: oily, metallic, tallowy, fishy?
6. Discuss causes and prevention of leaky body in butter.

7. List the causes of mealy or crumbly butter; of sticky butter.
8. State causes of uneven color in packed butter other than that known as mottles.

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CHAPTER 14

BUTTER MARKETING

Quality of Butter. The first step in successful marketing consists of having a good product to sell and one which is uniform in quality. A large output is an additional factor in securing and holding a market. A million pounds of butter produced in 10 creameries with a volume of 100,000 pounds each is less desirable than the same amount produced in a single creamery. In securing large volume, however, the question of quality of cream and butter becomes an important consideration. Creameries with less volume but getting the cream from a limited territory may produce a higher grade of butter which will have superior marketing advantages. Economical marketing of cream and butter, therefore, may resolve itself into a proper balance between volume of output and quality of product. The suppression of either factor in the undue development of the other may result in marketing handicaps.

Markets and Prices. A product resulting from a well-balanced production plan, as indicated above, must be marketed to the best advantage. Price advantages in marketing may determine the permanency of the local creamery. A creamery may be producing a suitable volume of good butter and it may be operating with low manufacturing costs. If the manager is careless in following market prices and trends and gives all his attention to factory operations, he may find himself handicapped from the standpoint of net returns for his product. The successful operator today must carry out a well-balanced plan based on every angle concerned with net profits.

Primary Butter Markets and Price Variations. The five principal butter markets are New York, Chicago, Philadelphia, Boston, and San Francisco. Usually the three eastern markets pay about 1 cent more per pound of butter than Chicago for butter of the same grade. This about balances the cost of freight from

Chicago to the eastern markets. The quotations may vary, however, from no difference to as much as 3 cents more in eastern markets. Receipts on certain markets may be far in excess of demands. Imports of butter or expected arrivals may cause temporary price upsets.

In 1920 transportation difficulties caused by severe storms and railway strikes produced a difference of 7 to 10 cents per pound in the price of butter. Extreme conditions of this type are quite unpredictable. The creamery manager, however, should know when a favorable difference in price exists between certain markets and direct his shipments accordingly. Exceptions to this principle exist. If a creamery is dealing with a reliable buyer who cares to reduce appreciable price differences to the advantage of the creamery in order to retain patronage, there may be every reason why sales should continue to the same buyer.

Federal Market Quotation Service. The Bureau of Agricultural Economics of the United States Department of Agriculture supplies daily market quotations, free of charge, to all who request them. These are a valuable guide to creameries. The information reported (by post card) is given opposite. It should be studied and explanations offered for the following facts:

1. Higher prices in eastern markets.
2. Slight price difference between standards (90 score) and extras (92 score).
3. Chicago centralized carlots (standards) sell for same price as (extras) in less than carlots.

Exchange quotations are used extensively in the selling of butter. There has been considerable diversion of butter sales because of direct marketing by individuals, cooperative agencies, and centralized concerns so the total exchange volume is less and its sales may not represent current sales prices so accurately because of less total sales volume. Contract sales also further decrease open market trading. Contracts based on current market prices of a certain market may cover a twelve-month period.

Quotations by the Federal Bureau of Agricultural Economics, based on a 3 P. M. closing hour, may differ from prices reported earlier in the day. Earlier reports from commercial price reporters

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF AGRI. ECONOMICS

MARKET NEWS SERVICE
1103 NEW P. O. BLDG., CHICAGO, ILLINOIS
MONDAY, FEBRUARY 1, 1937

WHOLESALE SELLING PRICES OF CREAMERY BUTTER—(IN TUBS)

SCORES	CHICAGO	NEW YORK	PHILA.
93	$32\frac{1}{2}$–$32\frac{3}{4}$	$33\frac{1}{2}$–34	34
92	$32\frac{1}{4}$	33	$33\frac{1}{2}$
91	32	$32\frac{3}{4}$	33
90	$31\frac{3}{4}$	$32\frac{1}{2}$	$32\frac{1}{2}$
89	$31\frac{1}{2}$	32	$32\frac{1}{4}$
88	—	$31\frac{3}{4}$	—
87	—	$31\frac{1}{2}$	—
	CENTRALIZED CARLOTS		
90	$32\frac{1}{4}$	—	—
89	—	—	—
88	—	—	—
RECEIPTS:	7,718	10,573	935
MARKET TONE:	ABOUT STEADY	FIRMER	FULLY STEADY

10 MARKETS STORAGE HOLDINGS

A. M. TODAY	CORRES. DAY LAST YEAR
23,557,640	13,229,224

MONDAY,
FEB. 1, 1937

C. L. PIER LOCAL REPRESENTATIVE

may go to the press or to the radio and not represent the general market tone later in the day. Both market tone and volume basis of sales are more indicative at the later hour.

Premium sales present difficulties for the market reporter. Contracts based on New York extras (92 score) and granting one-half cent over may result in some uncertainty as to just what actual sales prices are. Human psychology, however, seems to be gratified by an apparent premium price.

C. L. Pier, federal market specialist, describes the government's method of determining daily market prices:

> Each morning a representative of this office attends the session of the Chicago Mercantile Exchange, records the sales, bids and offers on the spot and future butter call.
>
> We canvass the market thoroughly both by personal calls and by telephone, contacting wholesalers, jobbers, brokers, chain

stores, and meat packers who operate creameries. We obtain as complete a record of the sales of butter of the various grades as possible up to 3 P. M, each day giving consideration to the prices at which the larger quantities are sold in arriving at our price.

There is a price established at 10 A. M. by a commercial reporting agency. We often find that conditions change during the day and prices may be higher or lower.

Problems Encountered in Establishing Quotation. The problem of reporting wholesale butter prices is becoming continuously more difficult according to L. M. Davis of the United States Bureau of Agricultural Economics.[1] There are several factors which enter to make the total volume of wholesale transactions less from time to time. Some of these are:

1. Increase in sales on contracts.
2. Payment of premium prices over daily market quotations and off-the-record sales.
3. Increase in direct sales to chain stores.
4. Cooperative marketing organizations sell most of their butter direct to consumers or distributors.
5. Centralized creamery butter is usually sold direct to consumers through their own agencies.

The need of price quotations is definite. The decreasing amount of butter sold and reported as *bona fide* sales makes it more difficult to report prices which are representative of most of the butter sold.

Mercantile Exchanges. The Mercantile Exchanges of Chicago and New York in particular do perform a valuable market service. They are well organized and governed by very strict rules. All sales made on these exchanges are *bona fide* sales and are therefore reliable from the standpoint of price quotations. In this respect alone they perform a valuable service.

Some facts regarding the Chicago Mercantile Exchange given by its president[2] are summarized here.

> The Chicago Mercantile Exchange is a cooperative organization consisting of about five hundred members from all parts of the United States and Canada. The Exchange as an organization does not buy and sell. It formulates the rules governing its functions and the transactions of its members, acting as a police service to see that all transactions are properly made and com-

pleted. Both cash and futures markets are provided. The cash market requires that all transactions be posted on the blackboard and that delivery is made on the day of sale or not later than noon of the next day. It is the duty of the Exchange to inspect the produce and declare it to be the grade specified.

The Exchange establishes no prices. A representative of a private agency is given the privileges of the floor and makes his own decisions as to prices and trends in both supplies and prices. These are printed in the *Chicago Price Current*.

The futures market is considered a very essential part of the operations of the Exchange. Both buyer and seller must conform to the rules of the Exchange. They, as dealers, establish the quantity, grade, date of delivery, and the price, but in compliance with rules, except for price. The Exchange sees that these transactions are completed as specified. In case a member fails to fullfil his contract, the Exchange then becomes the insurer of the contract for the other member.

Futures. Dealing in futures is a logical procedure. Market prices may become excessively depressed or raised, depending on present supplies and visible or prospective supplies. Trading in futures tends to forecast prices and acts as a general stabilizing factor. Such trading may be carried on at times in a prejudicial manner and the results may not be all that could be desired. A little adverse influence, however, does not condemn the practice, for its benefits far outweigh slight abuses which may creep in.

In the belief that there is a definite lack of knowledge with respect to the procedures, methods, and objects of produce exchanges, we present a rather detailed outline of the practice of "hedging" as described by Dr. Van Norman of the Chicago Mercantile Exchange. A creditable knowledge of the marketing of butter must include the part which produce exchanges now play and their importance in the history of marketing.

HEDGING PRACTICE—PRICE INSURANCE

(Abstract of address by Dr. H. E. Van Norman of the Chicago Mercantile Exchange before a State Creamery Operators' Association, 1936)

For the purpose of this discussion terms used are defined:

1. *Manufacturing Profit.* Return on investment, labor employed, butterfat bought, butter sold to distributor.
2. *Merchandising Profit.* Reward for distribution service.

3. *Ownership* for profit from price change is speculation.
4. *Holding* spring surplus for consumption during winter shortage is *speculation.*
5. *Speculation* in storage butter and eggs is an essential service to producer and consumer.
6. *Storage* holding involves 2 risks:
   Destruction by fire.
   Loss from price change.
7. *Insure* against loss from (*a*) fire, by an *insurance* policy; (*b*) price change, by *hedging contract.*
8. *Hedging* practically eliminates loss from price change.
9. *Hedging* transfers the risk of price change to a speculator.
10. *Hedging* is done by making a selling contract to deliver at a definite future time a specified commodity at a certain price and place. (See hedging booklet of Chicago Mercantile Exchange.)
11. *A hedging* contract is fulfilled by delivery of the commodity, or of a *contract to buy* as an *offset against* a selling contract, according to rules of the Chicago Mercantile Exchange.
12. 1935 *Storage Reserve.*
    159 million pounds of butter.
    212 million dozen eggs.
    The producer was paid—speculators took the risk of price change.
13. *A Market Place.* Where seller and buyer meet to transact business.
14. *An Exchange.* An *organized market place* conducted according to established *rules* by *qualified members,* with severe penalties for infraction of rules.
15. *Hedging Contracts* are made on an Exchange organized for future trading, such as the Chicago Mercantile Exchange.
16. *Contracts for Future Delivery* are for car lots—19,200 pounds—Exchange inspected, standard 90-score butter deliverable during a specified month (seller may choose the day).
17. *Orders* "to sell" or "to buy" for future delivery for non-members must be placed through members.
18. *Charges.* Commission (for non-members on one car lot of butter—$50.00, clearing-house fee and government tax about $4.00.
19. *Hedge*—When?
    (*a*) Definite profit is better business than a possible loss.
    (*b*) When you cannot afford a decline in market price.
    (*c*) When you have an acceptable profit.
    (*d*) When you think the market peak is reached.
    (*e*) When on a declining market, you cannot afford further loss.
20. *Profit*—A small profit on all sales is usually more profitable in the long run than big profits on some sales and big losses on others.

AN EXAMPLE OF HEDGING

On July first a creameryman has a car of butter which, because this is the heavy production season, he cannot sell to advantage right at the moment. He finds that the market on storage standards for November delivery is 27 cents and decides to store the car and hedge it.

His manufacturing costs plus the storage he would have to pay to carry the car into November amounts to 26½ cents. A November delivery contract at 27 cents will insure him a ½-cent profit on the car. This he considers a fair manufacturing profit, so he makes a contract to sell for November delivery.

By doing this, he, of course, eliminates the possibility of making a larger speculative profit in case the market should advance considerably before November. But he, being a smart operator, prefers a sure profit of ½ cent a pound on the car rather than taking a chance of getting a greater profit, with an equal chance of taking a bad loss should the market decline while he held the car in storage.

HIS CAR IS NOW HEDGED—HIS WORRIES ARE OVER

It cost him $50.00, plus clearing house fee and small government tax, total about $4.00, to hedge the car. It was well worth it because—

Production was heavy that year, butter plentiful, and consequently the price declined.

During June and July the market declined 1 cent, which represented a loss of approximately $192.00 on his car in storage. But, during that period, on his futures contract he had been credited with $192.00 profit on his broker's books because he could "buy in" his hedge for less than he sold for. This he can leave on the books until the contract is closed out, or he can draw it sooner.

During the next three months the market declined another cent, another loss on the car in storage, and another profit on his futures contract.

November, the contract delivery month, arrives. The market price on the butter which cost him 26½ cents is now 25 cents, a loss of $288.00. However, this loss is wiped out and his profit assured by the $384.00 he has made on the futures contract. Out of this profit, of course, he has to pay his broker's commission and the government tax which amount to about $56.00, leaving him with a net profit of about $40.00 on the entire transaction as against a $384.00 loss had he not hedged.

This creameryman has a fine reputation for handling good butter so that he can market the car through his regular channels at 1 cent *or more,* above the current market for storage standards. He can sell the car outright at 26 cents.

Through foresight in the summer and good merchandising in the fall, the creameryman has handled his car of butter successfully. He has secured a profit of 1½ cents per pound, even the brokerage charge and government tax being offset by the fact that he was able to market the car at 1 cent above the price he would have secured had he delivered the car on his futures contract.

HEDGING STEPS

July 1		
(1) Owns 1 car lot, cost......	.25	
Storage to November ..	.01½	
Manufacturing profit .	.00½	
	——	(2) Makes a selling contract for November delivery 1 car lot @ .... .27
	.27	
		(3) Market declines
		(4) November 1st removes hedge by making *buying contract* to offset No. 2—1 car lot @............ .25
(8) Decline on butter	.02	(5) Profit on futures contract .02
	——	
(9) November 1st price..	.25	(6) Buying contract (4) "offsets" and fulfills, according to exchange rules, selling contract (2).
		(7) Profit (5) offsets decline (8).

He now has his car free from the hedging contract. If sold at .25, he had a ½-cent manufacturing profit. If because of quality and reputation he can sell for more, he has a merchandising profit in addition.

If price had gone up 2 cents the loss would have been on the contracts and profit on the butter; he would still have had only his manufacturing profit plus his merchandising profit.

By these steps the risk of loss from price change was taken by the speculator who bought for November delivery, hoping to sell at a profit. As soon as the market declined a little the speculator would sell to another speculator and so on, each taking a small loss, as compared with the owner's large loss if he had not hedged. On the other hand, if the market had gone up, each of the speculators would have had a small profit; the total profit equaling the rise in the market, and the creameryman would have netted only the ½-cent profit at the price he hedged.

The large holder of *unhedged* storage lots takes all the risk. Each of the speculative buyers of hedging contracts takes *part* of the risk, usually in small lots.

Rules on Classification and Grades — Chicago Mercantile Exchange. The rules governing the classification and grades of butter on the Chicago Mercantile Exchange are given in Appendix B of this book. This information is frequently essential to a complete understanding of market quotations which appear in trade papers and as given in radio reports.

Four Primary Butter Markets. The most complete and authoritative market quotations on butter come from the four primary market centers, viz., New York, Chicago, Boston, and Philadelphia.

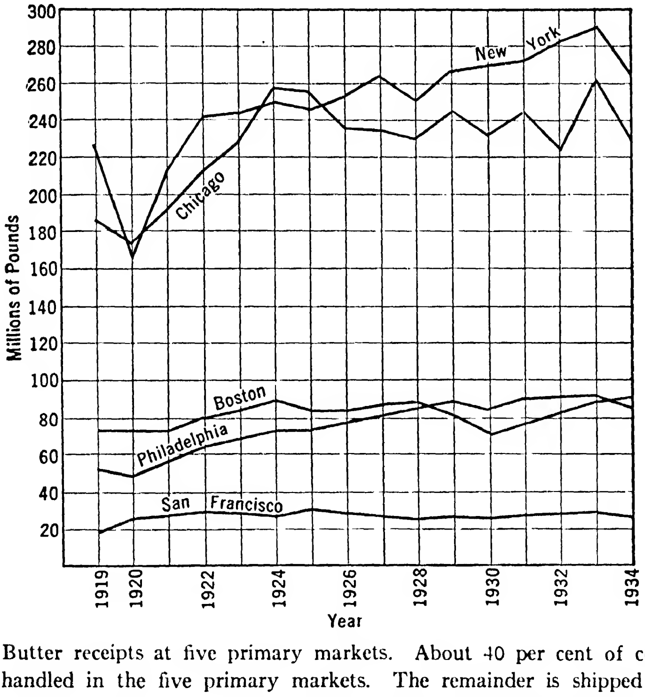


FIG. 85. Butter receipts at five primary markets. About 40 per cent of commercial butter is handled in the five primary markets. The remainder is shipped to minor markets, or any market, or is sold direct to chain stores, restaurants, hotels, etc. The cooperative marketing agencies do much direct marketing and their sales are not recorded in the produce exchanges. U.S.D.A. Yearbook, 1935.

Western market quotations come largely from San Francisco, with Seattle and Portland making contributions on deliveries and prices. (See Fig. 85.)

Receipts of butter on two of the larger markets have been as follows:[3]

Year	New York, 64-Pound Tubs	Chicago, 64-Pound Tubs
1926	3,462,218	3,189,635
1927	3,585,551	3,124,044
1928	3,445,416	3,071,353
1929	3,630,753	3,250,216
1930	3,672,194	3,111,870
1931	3,756,410	3,243,375
1932	3,870,133	3,009,382
1933	4,034,009	3,584,036
1934	3,656,345	3,114,269
1935	3,308,534	3,141,946
Ten-year average	3,642,156	3,184,012
Per cent of total U. S. production	14.0	12.7

Year	New York 64-pound tubs	Chicago 64-pound tubs
1936	3,816,000	3,522,000
1937	3,638,000	3,683,000 (exceeds New York)

These figures for 1936 and 1937 are not included in the totals. In 1937 there existed the unusual condition when receipts of the Chicago market exceeded those of the New York market.

Annual receipts on five markets for the ten-year period, 1926-1936, amounted to about 38 per cent of the total production of factory butter in the United States.

New York	14.0%	Cooperative organizations about	20.0%
Chicago	12.7	Chain store outlets	—
Boston	5.0	Centralizer creamery direct outlets	—
Phildaelphia	4.8	Other direct sales	—
San Francisco	1.5	Other lesser market centers as St. Louis, etc.	—
Total	38.0%	Total	62.0%

Price Stabilizing Factors. Of interest to producers, consumers, marketing agencies, and others are the data presented in the graph herewith reproduced from "Farm Economics," No. 100, March 1937, page 2456, Department of Agriculture, Economics and Farm Management, Cornell University.[4] Violent and wide seasonal price fluctuations are moderated as supply and demand are partially controlled.

The accompanying graph showing seasonal price variations on the New York Market covers a period of 56 years. The leveling off of the price fluctuations curve is attributable to several factors.

1. Development of mechanical refrigeration and storage of large stocks at the season of peak production.

2. Operation of Mercantile Exchanges providing for future contracts. This stimulates activity in dull markets and curbs activity in bull markets.
3. Better production and manufacturing methods produce butter which will store and retain its quality.

Marketing. Of interest is the fact that since May, 1938, and continuing through November, the federal government has been buying butter in an effort to stabilize the price. Their efforts have resulted in establishing a level of about 25 cents per pound. A

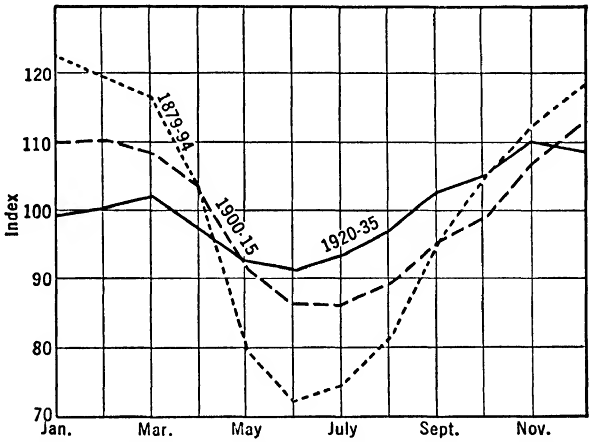


FIG. 86. Index numbers of seasonal variation in butter prices at New York, 1879-94, 1900-15, and 1920-35. The seasonal variation in butter prices has declined. Summer prices have risen in relation to winter prices.

previous attempt for about three months in 1933 (August to November) was similarly successful, and the price was stabilized at nearly the same level. Land O'Lakes was the buying agency in 1933. In 1938 the Dairy Products Marketing Association bought more than 100,000,000 pounds of butter in about 4 months. This is about 6 per cent of the total annual production. The United States Department of Agriculture has directed operations and has worked through the Dairy Products Marketing Association, with Land O'Lakes, Inc., buying in the Chicago market and Dairy and Poultry Cooperatives in the New York Market. The butter which has been bought is not a potential market supply. It will be allocated for relief purposes. Price stabilization has been effected.

The American butter market even under a partial price stabilization plan has had lower prices than London, which is the center of the world's butter market. Since May, 1938, London prices have been about 29 cents as compared to 25 cents in the United States. This is an unusual and unprecedented situation. We have a 14-cent per pound tariff on butter. This of course is entirely inoperative.

General Marketing Procedures. Four general procedures in selling butter are:

1. Sales to brokers and commission houses.
2. Sales to chain-store companies.
3. Cooperative marketing.
4. Chain creameries with well-organized sales outlets.

The first method listed is undoubtedly the oldest. Men operating as brokers and commission dealers learned, by long years of experience, the demands of consumers and the service they desired, together with many other phases of the business. They provided a cash market for butter and with but few exceptions were reliable. The local creamery could not sell directly. It could not store its butter and needed cash to pay its patrons. Competition among brokers kept prices to a reasonable level. At times there may have been collusion on the part of the buyers, which may sometimes even have been necessary to stabilize market conditions. The only neglected side in this scheme was the inability of the local creamery or the producer to protect his interests and to stabilize his selling operations. No doubt, overemphasis has been placed on the fact that the buyer sets the price and the local creamery, like the farmer, must take whatever he can get. However, intelligent group selling places the local creamery in a position of sales power which it otherwise would never have. Hence, we have the development of cooperative sales agencies.

The best-known organizations of this sort are:

1. Land O'Lakes Creameries, Inc., Minneapolis, Minn.
2. Iowa State Brand Creameries, Inc., Mason City, Iowa.
3. Challenge Cream and Butter Assn., Los Angeles, Calif.
4. Dairy and Poultry Cooperatives, Inc., Chicago, Ill.
5. Interstate Associated Creameries, 1319 S. E., 12th Ave., Portland, Ore.
6. Midwest Producers Creameries, South Bend, Indiana.

Cooperative Marketing. Cooperative marketing in general has had remarkable growth in the past twenty-five years. In the marketing of butterfat, the organization of the farmers' cooperative creameries in Minnesota for twenty years following 1895 represents some of the early efforts in cooperative work. Professor T. L. Haecker preached the gospel of cooperation and made great sacrifices to promote this work.

Land O'Lakes Creameries, Inc. With the phenomenal growth of farmers' cooperative creameries in Minnesota, the time arrived when a large cooperative selling agency seemed to be the next logical step. In 1921, such an organization was established, known as the Land O'Lakes Creameries, Inc., of Minneapolis, Minn. Its objects are:

1. To improve and standardize the quality of cream and butter for members.
2. Find new markets for good butter under a single advertised trademark.
3. To effect savings in buying creamery and farmers' supplies.

DAIRY AND POULTRY PRODUCTS HANDLED BY LAND O'LAKES CREAMERIES, INC., MINNEAPOLIS, MINN., 1924–1937

Year	Butter, 1,000 pounds	Cheese, 1,000 pounds	Milk powder, 1,000 pounds	Eggs, 1,000 cases	Poultry, 1,000 pounds	Dressed turkeys, 1,000 pounds
1924	32,842	. . . . .	. . . .	. . . .	. . . .	. . . .
1925	79,107	. . . .	. . . .	10	. . . . .	. . . .
1926	79,567	. . . .	733	. . . .	. . . . .	. . . .
1927	84,257	. . . .	2,937	. . . .	. . . . .	. . . .
1928	86,649	. . . .	7,865	108	1,197	. . . .
1929	93,115	. . . .	20,819	53	3,396	. . . . . .
1930	100,993	. . . .	19,150	106	3,272	. . . .
1931	98,215	. . . .	13,193	113	. . . . .	2,927
1932	98,138	4,539	12,625	125	4,243	5,541
1933	98,392	7,084	5,328	107	4,818	5,959
1934	85,018	23,250	5,419	153	4,074	4,811
1935	78,816	24,074*	9,063	155	4,478	4,022
1936	74,154	21,329*	5,131	216	2,912	5,800
1937	70,941	20,319*	8,926	172	3,561	4,778

* Units not pounds.

The growth of Land O'Lakes, Inc., is entirely creditable to its management and its purposes. New lines of endeavor have been added, and the figures above give some conception of their growth and of the products handled.

As a result of persistent efforts to improve the quality of cream and butter in member creameries, Land O'Lakes, Inc., is able to present the information given in the table below.

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS
MINNESOTA STATE DEPARTMENT OF AGRICULTURE

SUMMARY OF BUTTER GRADED FOR LAND O'LAKES CREAMERIES, INC.
JANUARY, 1937

Per Cent of Various Scores, Including All Districts

	93 and Above	92 Score	92 and Above	91 Score	90 Score	89 Score	88 Score
January, 1937	82.99	10.74	93.73	4.68	1.19	0.24	0.23
" 1936	82.40	7.84	90.24	8.10	1.48	0.15	0.04
" 1935	74.36	11.61	85.97	10.20	3.56	0.63	0.09
" 1934	73.31	14.21	87.52	9.00	3.11	0.52	0.13
" 1933	77.64	9.13	86.77	9.54	2.87	0.75	0.11
" 1932	70.91	13.50	84.41	10.09	4.02	1.22	0.44
" 1931	63.00	18.92	81.92	9.77	6.00	1.36	0.94
" 1930	68.30	15.79	84.09	10.14	4.01	1.06	0 70
" 1925	40.51	23.36	63.87	20.69	11.87	3.00	0.67

C. W FRYHOFER
Supervising Federal-State Butter Grader

Please note the increase in high-scoring butter in twelve years and the decrease in butter scoring 90 or below. Great credit is due the Land O'Lakes organization for its persistent work in quality improvement. It is a manifestation that a *quality product* is one of the primary considerations in successful marketing.

Iowa State Brand Creameries, Inc. The requirements and purposes of the Iowa State Brand Creameries, Inc., are set forth in Bulletin 51, issued by the Iowa Department of Agriculture in 1934. We must not fail to point out that great credit is due Dr. M. Morten-

FIG. 87. Printing butter. Spacious, sanitary butter-printing room in the Land O' Lakes plant, Minneapolis, Minn. Note the automatic printing and wrapping machines at the left. The girls seated at the long tables wrap and carton pound prints of butter coming from hydraulic presses.

FIG. 88. Modern testing laboratory. The laboratory is essential in large dairy plants. Land O' Lakes serves its many member creameries with its central laboratory in Minneapolis. Courtesy Land O' Lakes, Inc.

sen, head of the Department of Dairy Industry at Iowa State College, for the promotional work that led to the completion of the organization. Iowa State Brand Creameries, Inc., in 1938 handled the output of 73 creameries in northern Iowa and southern Minnesota.

AMOUNT OF BUTTER HANDLED BY IOWA STATE BRAND, INC.

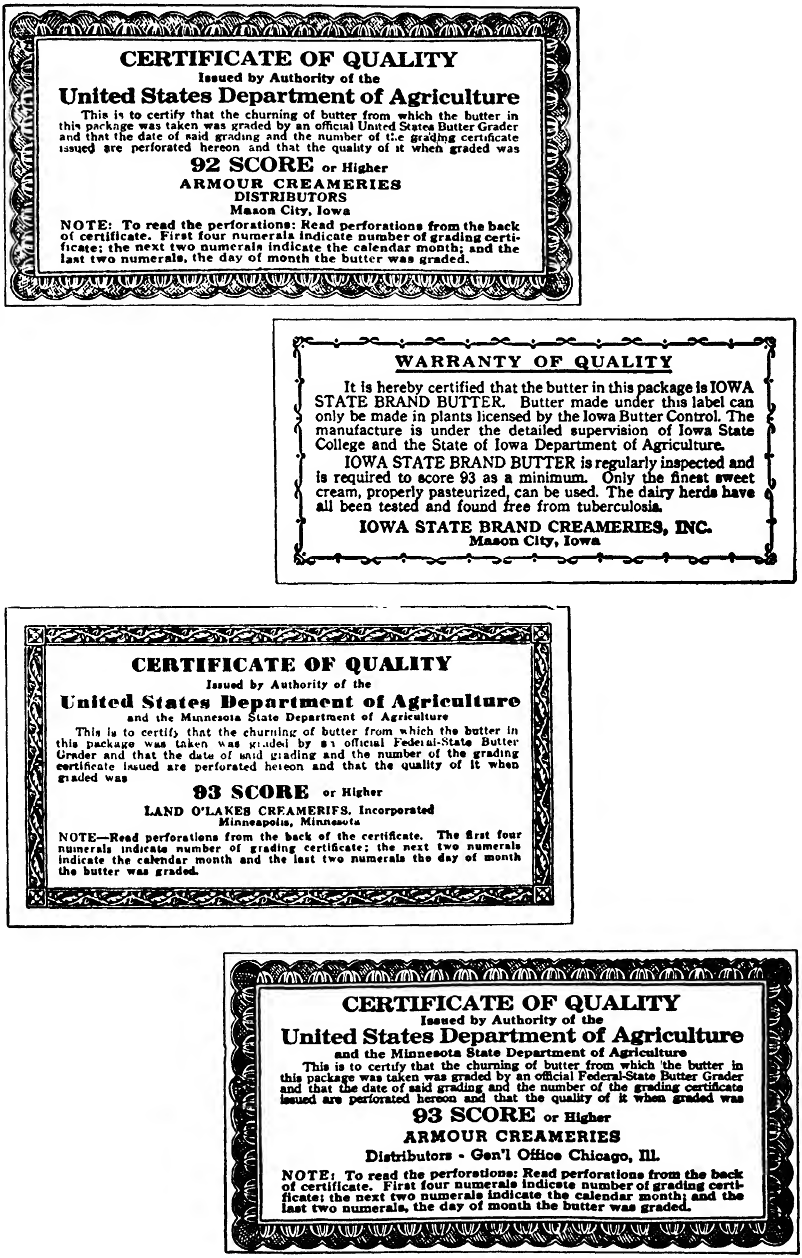
1927	Less than 100,000 lb.
1928	2,189,000 "
1929	4,982,000 "
1930	6,866,000 "
1931	10,240,000 "
1932	12,727,000 "
1933	13,589,000 "
1934	15,579,000 "
1935	16,278,000 "
1936	16,535,973 "
1937	17,740,399 "
1938	19,659,547 "

Because of the fact that state control of marketing of a product is rather unique in the United States we supply the text of the Iowa Law in Appendix C of this book. Similar control is practiced by several countries, as for example, Denmark, Sweden, and the continent of Australia.

FIG. 89. "Iowa State Brand." Used for Iowa butter of first quality.

No attempt is made in the Iowa law to regulate prices. Attention is centered on providing a product of high quality with a distinctive and exclusive brand. As a matter of course, marketing and price advantages must follow.

Certificates of Quality. The use of certificates of quality in retail sales packages is intended to promote the sale of high-grade butter. Authoritative quality certification gives the butter consumer



CERTIFICATE OF QUALITY
Issued by Authority of the
United States Department of Agriculture
This is to certify that the churning of butter from which the butter in this package was taken was graded by an official United States Butter Grader and that the date of said grading and the number of the grading certificate issued are perforated hereon and that the quality of it when graded was
92 SCORE or Higher
ARMOUR CREAMERIES
DISTRIBUTORS
Mason City, Iowa
NOTE: To read the perforations: Read perforations from the back of certificate. First four numerals indicate number of grading certificate; the next two numerals indicate the calendar month; and the last two numerals, the day of month the butter was graded.

WARRANTY OF QUALITY
It is hereby certified that the butter in this package is IOWA STATE BRAND BUTTER. Butter made under this label can only be made in plants licensed by the Iowa Butter Control. The manufacture is under the detailed supervision of Iowa State College and the State of Iowa Department of Agriculture.
IOWA STATE BRAND BUTTER is regularly inspected and is required to score 93 as a minimum. Only the finest sweet cream, properly pasteurized, can be used. The dairy herds have all been tested and found free from tuberculosis.
IOWA STATE BRAND CREAMERIES, INC.
Mason City, Iowa

CERTIFICATE OF QUALITY
Issued by Authority of the
United States Department of Agriculture
and the Minnesota State Department of Agriculture
This is to certify that the churning of butter from which the butter in this package was taken was graded by an official Federal-State Butter Grader and that the date of said grading and the number of the grading certificate issued are perforated hereon and that the quality of it when graded was
93 SCORE or Higher
LAND O'LAKES CREAMERIES, Incorporated
Minneapolis, Minnesota
NOTE—Read perforations from the back of the certificate. The first four numerals indicate number of grading certificate; the next two numerals indicate the calendar month and the last two numerals the day of month the butter was graded.

CERTIFICATE OF QUALITY
Issued by Authority of the
United States Department of Agriculture
and the Minnesota State Department of Agriculture
This is to certify that the churning of butter from which the butter in this package was taken was graded by an official Federal-State Butter Grader and that the date of said grading and the number of the grading certificate issued are perforated hereon and that the quality of it when graded was
93 SCORE or Higher
ARMOUR CREAMERIES
Distributors - Gen'l Office Chicago, Ill.
NOTE: To read the perforations: Read perforations from the back of certificate. First four numerals indicate number of grading certificate; the next two numerals indicate the calendar month; and the last two numerals, the day of month the butter was graded.

FIG. 90. Authorized quality certificates inserted in retail packages of butter.

assurance that he is buying butter of a superior grade. This is a fair-trade practice. It should result in advantages to the cream producer, the marketing agency, and the consumer.

The Bureau of Agricultural Economics of the United States Department of Agriculture grants the use of such certificates and supplies official graders. These graders are stationed where sufficient amounts of butter are concentrated to justify the expense of maintaining them.

"Iowa State Brand" quality certificates are not granted by the federal service. Instead they are authorized by the Iowa State College and the Iowa State Department of Agriculture.

The Pacific Coast States, particularly the state of Oregon, have made some use of certificates. An Oregon law authorizes the use of a certificate of quality to be placed in retail packages at the individual creamery. These certificates show grades as A, B, and C. If a creamery is granted the use of A certificates and the quality of its butter falls below this grade, state authorities notify the creamery to discontinue the use of the A certificate and indicate the proper one to use.

California also has a law requiring the use of consumer grades, from which tangible results have been observed. Not only has the quality of California butter improved, but since San Francisco is the fifth largest butter market in the United States, and because much coastal and intermountain butter is marketed there, improvement is also noted in the quality of butter from surrounding states.

Canada has legally adopted consumer grades in all provinces except Nova Scotia. British Columbia and Alberta were first to adopt the grades, their laws becoming effective May 1, 1935. This may have been because of their proximity to our Pacific Coast states, which enacted laws about this time. Other Canadian provinces followed in this order: Saskatchewan and Manitoba in June, 1935; Ontario in the spring of 1936, the law becoming operative in September, 1936; New Brunswick, May 1, 1937; Quebec, June 1, 1937. Chief inspector W. C. Cameron of Ottawa states that the public is becoming "grade conscious" and that butter prices are more in line with actual quality. More careful grading of cream is observed, and the general quality is improving. It should be understood that these statements have definite reference to the influence of consumers' grades because Canada has had effective cream-grading laws since 1923, as described in Chapter 6, "Buying and Grading Cream."

All such grading efforts are highly commendable and are to be encouraged. They are in agreement with pure-food laws and the proper labeling of food products. *It is most important, however, that butter be graded as near as possible to the time it is placed in retail stores for consumer trade.*

The Iowa State Brand Creameries, Inc., pays a fixed price for butter of a definite grade and does not pool as Land O'Lakes does. Its brand name or trademark is established by legislative act, whereas the Land O'Lakes Company is a private enterprise. In partial state control, Iowa State Brand resembles methods used in Europe. The Lur Brand of Denmark, the Rune Brand of Sweden, and the Kangaroo Brand of Australia are fostered and controlled under comparable conditions of government supervision.

Iowa State Brand Creameries makes a very careful survey of creameries wishing to use the marketing facilities of the organization. The creamery must produce a uniformly high grade of butter. It must seek admission. It must be licensed, and such license may be revoked.

Both the Iowa State Brand Creameries and Land O'Lakes conduct laboratory services, and educational work is a very important part of their program. Butter-composition control, shrinkage losses, correct and careful weights in tubs are a few of the considerations. Large economic gains have accrued to the creameries as a result of this work.

The Dairy and Poultry Cooperatives, Inc., of Chicago, Ill., operate as explained in a letter dated May 26, 1936, which reads as follows:

> We are set up as a cooperative organization and comply with the provisions of the Capper-Volstead Act. We use the revolving fund method to create a working capital. The member creameries ship us their butter on a consignment basis. It is sold to the best possible advantage. A handling charge, estimated quarterly in advance, is set by the Board of Directors. During the current quarter that handling charge is fixed at 38/100 cents per pound of butter or poultry or per dozen eggs.
>
> In addition to the handling charge, we deduct from the account sales on each shipment from members' business only ⅓

cent per pound which is set up in a revolving fund to create working capital. At the end of each month a certificate of interest is returned to the members covering the amount deducted for the month. These certificates of interest bear interest at the rate of 3 per cent per annum. These certificates are not dated. They will be revolved entirely at the discretion of the Board of Directors. It is our plan to build this revolving fund up to our minimum requirements, before it is revolved. Our estimate of that at the present time is $100,000.00. We have been following this plan for a little over a year only. The capital stock originally subscribed was converted into certificates of interest so that at the present time our total capital fund is in the neighborhood of $65,000.00.

The handling charge, as above stated, is charged quarterly, trying to keep that charge as near actual costs as possible.

We are permitted under the Capper-Volstead Act to transact up to 50 per cent of our volume of business with non-members. We do have quite a fair percentage of business with non-members and we charge them the regular going rate of commission for handling their sales. Non-members do not participate in the earnings of the organization.

Our sales are made largely to jobbers. We confine ourselves strictly to a wholesale business. We are not attempting to sell directly to hotels, restaurants, and individual grocers. That field is very crowded, competition is intense, and profits are exceedingly small except when an immense volume of business is transacted. Great investments have to be made in accounts receivable. Therefore, we keep away from that end of it and feel confident we have not lost money by failing to conduct a jobbing department of our own up to date.

The Midwest Producers Creameries, Inc., of South Bend, Indiana, handled the output (1938) of twenty-one strictly cooperative creameries. Most of these are creameries of large volume. They must own stock in the cooperative marketing agency. They market butter in tubs, prints, rolls, and paper boxes as prepared by the creameries. They sell to butter-distributing organizations, independent chain organizations, and chain stores. In 1935, 28,000,000 pounds of butter were marketed. They have been able to net these twenty-one creameries one-fourth cent to one-half cent per pound of butter more than they received when making their sales separately. They assess one-eighth cent per pound of butter to finance the organization, and any unused portion accrues for developing new lines of service. They have established a laboratory for butter analysis and yeast and mold counts.

The member creameries are located as follows:

1938

Michigan	10	plants
Indiana	7	"
Tennessee	3	"
Illinois	1	"

Purchase of equipment and supplies is a part of the work done for these creameries. A central warehouse stores supplies and provides quick service. In 1935 about $250,000 was used in this department, and the savings to the member creameries about offset their assessments.

Other midwest associations are:

Illinois Agr. Association
508 South Dearborn St., Chicago, Ill.
(7 plants in Illinois)
Southwestern Iowa Cooperative Creameries, Inc.
Keosauqua, Iowa (organized 1935)
Nebraska Cooperative Creameries, Inc.
Omaha, Neb.
(or Dept. of Dairy Husbandry, University of Nebraska, Lincoln).

The Challenge Cream and Butter Company of Los Angeles is the fifth large marketing association established on the Pacific Coast. Four previous organizations failed. The reasons for failure were chiefly lack of sustained cooperative effort and severe competition from regularly established private buyers. The first cooperative marketing association in California was the Dairymen's Union of San Francisco, organized in 1891. With the closing of this institution there followed the Oregon Cooperative Dairy Exchange in 1916, the Oregon Dairymen's Cooperative League in 1917, the Associated Dairymen of California in 1917. The Challenge Cream and Butter Company was organized in 1911. It has enjoyed a healthy growth, marketing 36,103,039 pounds of butter in 1931.

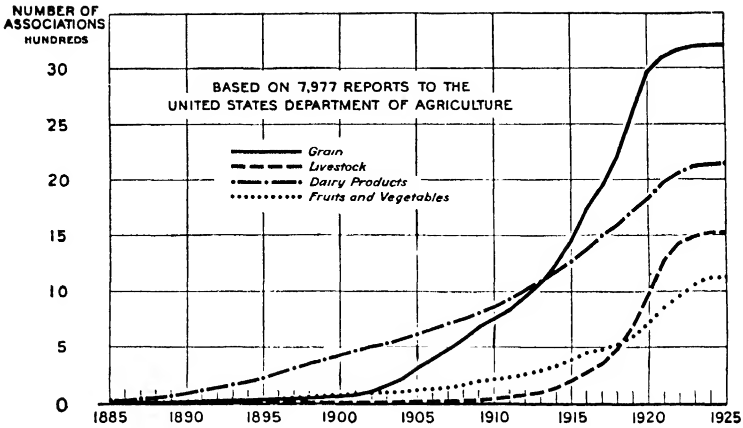


FIG. 91. Growth of cooperative marketing associations. Cooperative marketing of dairy products has had a steady and consistent growth. The trend since 1925 has been upward. Courtesy McKay and Lane, "Practical Cooperative Marketing," John Wiley & Sons, Inc.

Cooperative Marketing Not a Panacea. Cooperative marketing associations were encouraged in 1930 when the Federal Farm Board proposed a cooperative plan which affiliated Land O'Lakes, Challenge Cream and Butter Association, United Dairyman's Association of Seattle, and the Interstate Associated Creameries of Portland. Competition among these cooperatives in the same regions was largely eliminated, and they now cooperate in sales in their respective sections to the mutual advantage of all. The *cooperative marketing agencies handle about 20 per cent* of the total creamery-butter production in the United States.

Cooperative marketing organizations are wholly justifiable, as are cooperative manufacturing enterprises represented by farmers' co-operative creameries. They must be soundly financed, capably managed, and loyally supported. They are not a panacea; rather they must be considered a regular business undertaking and they must contend with the same vicissitudes of business as private enterprise.

A very sensible statement of fact was set forth by A. J. Glover, editor of *Hoard's Dairyman,* in an address to the National Creamery Buttermakers Association in St. Paul in 1928. Speaking of the manufacturing of butter, he said he believed we needed all three types of creameries, viz., the privately owned, the central type creamery, and the farmers' cooperatives. If one type of organization flourishes and others wane, then it must be that it is serving better. This thought is applicable to cooperative marketing as well.

President Coolidge on Cooperative Endeavor. Regarding cooperative endeavor, the late Calvin Coolidge said:

> We want cooperation preached as a principle, not a panacea. It will not perform miracles. It will not accomplish the impossible. But it is a sound, tried, demonstrated principle that must be introduced at the basis of our agricultural establishment. It demands that the individual shall surrender some part of his complete independence for his and for the general good. It means that a certain authority must be delegated, and when delegated it must be supported. There must be faith, good will, patience. It must be understood that no very spectacular achievement will be wrought.

Miscellaneous Facts on Marketing of Butter. These facts, related to the marketing of butter, have been listed by R. O. Storvick of the Iowa State Brand Creameries, Mason City, Iowa:

Parchment paper was first used about 1898.

The butter carton was first used in 1906. It became extensively used in 1918.

Butter was first stored in mechanical refrigerators and cold storage about 1900. The large cold-storage houses for butter appeared about 1920. (This does not mean that the practice of storage began in 1920. Many combination storage houses were in operation several years prior to 1920.)

The first shipment of unsalted butter was made from Omaha to New York in 1909. In 1938 New York alone consumed 20,000 tubs weekly of unsalted butter.

New York Mercantile Exchange was organized in 1875.

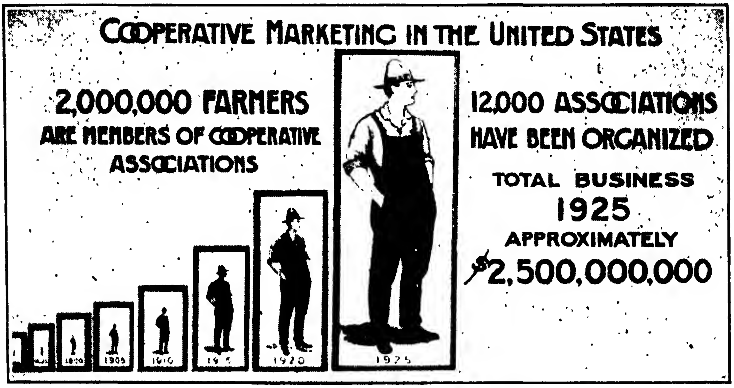
Chicago Mercantile Exchange was organized in 1882.

First grades and scores for butter were established by the New York Exchange in 1906.

Chain-store marketing started about 1919. A survey made in 1930 by the University of Iowa showed one-third of all groceries was marketed in chain stores. A total of 1025 chain systems with 80,469 stores was listed.

The large meat-packing establishments are now expanding rapidly in marketing butter.

Dairy Chains. The *American Creamery and Poultry Produce Review* in "Who's Who in the Dairy Industry," 1935, lists forty-five dairy chains. A number of these are engaged primarily in making and marketing butter. Examples of chains are: Borden's Produce Co., Fairmont Creamery Co., Beatrice Creamery Co., National



(*U. S. D. A.*)

FIG. 92. Cooperative marketing is well established. Courtesy McKay and Lane, "Practical Cooperative Marketing," John Wiley & Sons, Inc.

Dairy Products Co., Blue Valley Creamery Co., and Sugar Creek Creamery Co.

Marketing Trends. Present marketing trends may be summarized as follows:

1. Trend to finer quality.
2. Increased retail sale on basis of grade.
   a. Federal butter-grading service.
   b. Distributor's guarantee.
   c. Consumer's grade.
3. Trend to packaged goods.
4. Trend to closer cooperation between producer, manufacturer, wholesaler, retailer.
   a. Chain store (wholesaler and retailer).
   b. Packer (manufacturer and wholesaler).
   c. Cooperatives (producer, manufacturer, wholesaler).
5. Trend to stricter governmental regulation.

Printing of Butter. Most bulk butter is shipped to the central markets and consuming centers in tubs. The Pacific Coast States use cubes principally. The cubes are adapted in size to facilitate printing without deforming the mass of butter in cubical shape. This is highly desirable from the standpoint of preservation of body of butter.

In the central and eastern markets, tub butter is pressed through power-operated printers and is wire-cut into pound and

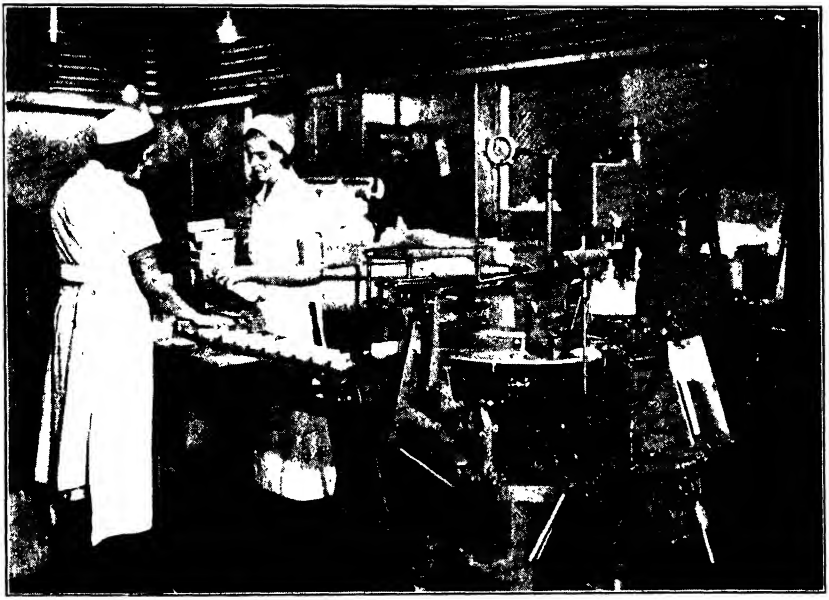


FIG. 93. New Swiss printer (used for printing soft butter directly from the churn) recently introduced in the United States shows possibilities of changing some present practices. Courtesy Walker-Wallace, Inc., Merchandise Mart, Chicago, Ill.

quarter-pound retail prints. These printers break down the butter with considerable crushing effect. The mechanical force is applied with an augur similar to that in the sausage grinder. Butter must be reasonably firm to form good prints. Pressing firm butter causes the expulsion of some brine from the mass of butter. The amount of brine lost depends upon the completeness of its incorporation in the butter. In other words, the more working the butter gets in the churn, the more completely brine is incorporated, the smaller the droplets, consequently less is lost in the printing operation.

The printers have been so insistent on more working to reduce printing losses that buttermakers have increased the amount of working from 25 or 30 revolutions of the churn (roller type) to 75 to 125 revolutions or more. Firm butter in the churn may be worked more with less danger of injuring its body. Nevertheless, there has been an increasing amount of sticky-bodied butter marketed. Consumers object to it because it does not spread well on bread. The use of mechanical refrigerators in homes is also a consideration. Temperatures in mechanical units average about 42° F., whereas the old-style ice box was seldom below 50° F. Sticky-bodied butter is much more objectionable if served cold.

New Swiss Butter Printer: Quite recently a new Swiss machine has been introduced in the United States (Fig. 93). This printer handles butter directly as it comes from the churn. The butter, therefore, comes in contact with no tubs or cubes, is handled less, and has less chance of contamination. This assertion, however, is not a certainty. These printers must be easily cleaned and must be kept clean. Printed butter has much greater surface exposure than bulk butter. Any contamination from printers would be highly objectionable.

The labor saved by direct printing from the churn is desirable. The Danish Creamery Association of Fresno, California, is very well pleased with this machine after six months' use. It cuts very accurate weights even on quarter-pound prints. Considerable savings are made on what formerly was overweight cuts. This machine cost $10,000 and handles 1000 pounds of butter per hour, cut and wrapped in quarters.

The use of this machine may be limited to large central plants. Rather direct outlets for butter would be advisable. There is, of course, the possibility that small plants in the heavy butter-producing areas may concentrate churn-fresh butter at nearby points and turn it directly into prints.

Whey-Cream Butter. Shortly after the introduction of the farm cream separator (about 1900) cheese-factory operators learned of the value of fat lost in whey. Whey was separated and by 1910 both New York and Wisconsin were providing considerable amounts of whey butter. Guthrie[5] records that 570,226 pounds of whey butter were made in 1922 in New York State.

Wisconsin makes about seven times as much Cheddar cheese as New York and we may assume that Wisconsin makes about 2.5 million pounds of whey butter. Many states have laws requiring whey butter to be labeled and sold as whey butter. Whey-cream butter frequently sells less readily and at a lower price. A question arises as to the fairness of this when the quality of whey butter is considered. Guthrie concludes that whey-cream butter and regular butter are both of satisfactory flavor, body, and keeping quality. The Wisconsin station reported whey butter equal or slightly superior in flavor score and keeping quality.

A possible explanation of superiority, if any, in whey butter is the fact that whey contains fewer bacteria than the milk from which it came. If whey cream is cooled promptly and delivered to a creamery, it may be made into very good butter. Truck routes gather whey cream daily and deliver it to creameries or to a cheese factory equipped to make butter. Guthrie further indicates that whey cream may be mixed with regular cream and if of equal grade, no ill effects in the butter can be found.

Making Whey Butter: Whey cream should contain 50 per cent or more of fat. This provides opportunity to add starter or skim milk for re-emulsification, reducing the fat content to about 30 per cent. It should be pasteurized in the regular manner. Starter, if used, should be added after pasteurization, as in making regular cream butter. Cool whey cream lower and churn at temperatures below those for regular cream. It is washed, salted, and worked in the regular manner.

QUESTIONS

1. Explain the usual relationship between quality butter and factory output.
2. Name the five primary butter markets.
3. Explain the basis of federal butter-price quotations.
4. Why is it increasingly more difficult to establish daily price quotations of butter?
5. What are "futures" in butter trading and of what merit are they?
6. What is hedging in the butter market?
7. What percentage of the annual production of butter is handled in the five primary markets? How is the remainder marketed?
8. List the reasons for decreasing market-price fluctuations during the past fifty years.
9. Name four general procedures in selling butter.

10. Name some of the best-known cooperative marketing agencies.
11. State three principal services which cooperative organizations perform for their members.
12. Explain the merits of certificates of quality as used in retail sales butter packages.
13. What is meant by dairy chains? Name some.

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4. Cornell University "Farm Economics," No. 100, March, 1937, page 2456, Dept. Agr. Economics and Farm Management.
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CHAPTER 15

DAIRY EQUIPMENT: METALS, DEPRECIATION, CARE

Metals Used in Dairy Equipment. The metals commonly used in the past for dairy equipment were tinned copper and tinned sheet iron. These are being rapidly replaced by stainless steel. Tin as a metal is very durable, relatively non-corrosive, and of low solubility in sweet milk and cream or sour milk and cream. It is too expensive to use alone in making equipment and is therefore used to plate iron and copper. Copper, although much more expensive than iron, has very definite advantages.

The advantages of copper compared to iron are:

1. Ductile—adapted to making coils.
2. Resistant to corrosion—long life.
3. Solders and tins readily.
4. High conductivity—rapid heat transfer.

Copper, therefore, as a base for tin plating has practical and economic advantages. Of the unplated single metals used in dairy equipment, aluminum has been found to be most suitable, particularly when costs are considered. It has been used in Germany, Switzerland, and some other European countries for at least twenty years. Wrought aluminum has very low solubility in milk and cream, either sweet or sour, is relatively resistant to attacks by dilute organic acids, and is a relatively good conductor of heat. It has the very definite disadvantage of susceptibility to alkalies. The use of washing powders is therefore restricted to those of very low alkalinity, in fact, wisdom forbids the use of any washing powder. Nickel as a single metal is expensive. Its use, therefore, has been in the form of alloys, typical of which is Monel metal.

Stainless steel is an alloy of iron, chromium, and nickel. It is commonly referred to as 18-8.

EFFECT OF METALS ON FLAVOR OF SWEET AND SOUR MILKS AND CREAMS
(Hunziker, Cordes, and Nissen, *Journal of Dairy Science*, Vol. 12, p. 140, 1929)

Metals	Sweet Milk		Sour Milks			Sweet Cream		Sour Cream		Sour Neut. Cream
	70° F. 5 days acid 0.15%	145° F. 5 hours acid 0.15%	Aci-dophilus 98° F. 5 days acid 1.76%	Butter Culture 70° F. 2 days acid 0.83%	Buttermilk 70° F. 5 days acid 0.29–0.87%	70° F. 5 days acid 0.16%	145° F. 5 hours acid 0.16%	70° F. 5 days acid 1.0%	145° F. 5 hours acid 1.0%	145° F. 5 hours acid 0.15%
Single Metals										
Aluminum	....	....	Sl. Met.	Sl. Met.	....	....	....	....	....	....
Copper	Tallowy	Sl. Met.	Sl. Met.	Metallic	Green Whey	Tallowy	V. Met.	Metallic	Metallic	Sl. Met.
Iron	Metallic	V. Met.	V. Met.	V. Met.	Metallic	V. Met.	V. Met.	V. Met.	V. Met.	Sl. Met.
Nickel	....	....	Sl. Met.	Sl. Bitter	....	Sl. Bitter	Sl. Met.	....	....	....
Tin	....	....	....	....	....	....	....	....	....	....
Zinc	....	....	V. Met.	Metallic	Sl. Met.	....	....	....	Sweetish	Metallic
Plated Metals										
Copper, tinned E.B. [1]	....	....	....	Sl. Met.	....	Bitter	Sl. Off	....	V. Met.	....
Copper, tinned E.T. [2]	....	....	....	....	....	Bitter	....	....	....	....
Copper Retin	....	....	....	....	....	....	....	....	....	....
Iron, galvanized	Fishy	Metallic	V. Met.	Metallic	Metallic	....	Sl. Off	Bitter	Sl. Bitter	Metallic
Iron, tinned E.B. [1]	....	....	V. Met.	V. Met.	Metallic	Sl. Met.	....	....	Metallic	Sl. Met.
Iron, tinned E.T. [2]	....	Metallic	Sl. Met.	Sl. Met.	....	Bitter	....	....	Metallic	Sl. Met.
Al. alloy, Al. plated	....	....	....	Sl. Met.	....	....	....	....	Metallic	....
Alloys										
Ascoloy	....	....	Metallic	....	....	....	....	....	....	....
Allegheny Metal	....	....	....	....	....	....	....	....	....	....
Enduro	....	....	Metallic	....	....	....	....	....	....	....
Monel Metal	....	....	....	Sl. Met.	....	....	Off	....	....	....
Nickel silver	....	Sl. Met.	Sl. Met.	Metallic	....	....	Metallic	....	Sl. Met.	....
Mn. Al. alloy	....	....	....	....	....	....	Sl. Met.	....	....	....

V. = very; Sl. = slightly; Off = off flavor. [1] Edges bare (not tinned). [2] Edges tinned.

The average composition of stainless steel is:

Chromium	18%
Nickel	8%
Iron or steel	74%

This alloy is found in commerce under several trade names, among which we find Allegheny metal, Ascoloy, Superascoloy, Enduro, etc. The proportions may vary somewhat, but the best grade of alloy demands a rather close adherence to the 18-8 formula.

Hunziker, Cordes, and Nissen [1] in 1929 studied the corrosive effects of milk and milk products on various metals, plated metals, and alloys. Both sweet and sour milk and cream, and dilute mineral and organic acids were used in the experiments. Allegheny metal, tin, and heavily tinned copper were quite outstanding in their resistance and low solubility in all the tests made. Stainless steels, other than Allegheny metal, resisted well in some tests but in others they pitted badly. Highly polished Allegheny metal proved to be very satisfactory.

Stainless steel is now being used widely in dairy equipment. Cream vats, however, must have some material other than stainless steel for coils. Stainless steel lacks ductility, and only coils of large diameter are possible. Welding or soldering of joints also presents difficulties. It is known also that certain stainless steels are affected by brine, whereas copper is but little affected. It is to be hoped that a suitable alloy of moderate price will soon be developed for coils. Retinning of a copper coil in a cream vat is nearly as expensive as retinning both coil and vat. Permanent metal surfaces must be provided. German silver and Monel metal have been used for coils but not with complete satisfaction from all angles.

Milk vats, starter cans, cheese vats, and some other equipment are well adapted to stainless steel and its use in their manufacture is to be encouraged. Although the initial cost is greater, the long life of the equipment, with low repair costs, is definitely advantageous. This alloy imparts, little, if any, metallic or other off flavors to products, even when relatively high acid conditions exist.

Spotting of Tinned Copper. The appearance of black spots on tinned copper cream vats has been observed for many years. Various explanations have been offered. Two precautions which delay spotting are:

A. Do not use washing powders without first dissolving them in water.

B. Dry the vat either by steaming with closed lids or by the use of a clean, dry cloth.

It is very probable that electrolytic action plays some part in the spotting of tinned copper. No two metals are of the same potential or degree of positive electric charge. When electrolytes are present, as in milk or cream or common tap water, we have the essential conditions for galvanic action. There may be deposition of metallic ions or oxidation of the metallic surface of the vat. Salts of the metals may be formed and in most instances these salts are far more soluble than the metals themselves. Spotting may result.

Practically all dairy equipment carries some electric charge. Even a milk can set on a cement floor shows some charge. Not only the inner vat surfaces may be the seat of electric currents, but metal parts in bearings may augment such electric impulses. Water connections on vats are now made of tinned bronze instead of iron, thus reducing the possibility of increased electrolytic action.

Electric currents may be set up in brine tanks which are connected with cream vats. Motor-driven vats may have stray currents from the attached motors. In fact, there are no doubt a number of unknown sources.

Retinning of Vats. Retinning should be done only by experienced and reliable men. Not only is the vat to be cleaned and the tin to be applied most carefully, but the kind of tin is of great importance. Good tinners will use an 80-20 solder (80 parts tin and 20 parts lead). This is more difficult to apply than 60-40 or 50-50 solder. The use of the latter, however, produces unsatisfactory results. It spots much more readily, and cannot be recommended. The vat manufacturer uses 100 per cent tin, which is applied by a special rolling process. It cannot be used in the field in retinning vats where a blow torch must be used.

Cream vats, forewarmers, starter cans, etc., should be kept in good condition. Such equipment when made of tin plate on steel or copper base will serve about four years without retinning. Length of service will depend much on use and care of equipment in washing and drying. Washing powders should be mild and should always be dissolved in water before being added to the water in the vat. Bronze "chore boys," when used, must be used judiciously. The thought of preserving the tinned surface must be kept constantly in mind. A stiff brush is preferable to any metal device for cleaning coils. As pointed out in Chapter 13, under "Color Defects in Butter," bronze particles, steel-wool particles, etc., which may be left in the vat, are likely to pass with the cream to the churn causing green or brown spots in the butter and a metallic or tallowy flavor. It is the part of wisdom to re-tin any vats which show appreciable corrosion. Skilled tinners should be employed and a good grade of tin used.

Metals Used in Coils. About 90 per cent of vats are now made of stainless steel. Vat coils, however, are still made from tinned copper tubing. Stainless steel is not used for these reasons:

a. Stainless steel lacks ductility. Coils made from it may spring out of shape and be unbalanced in rotation.
b. Stainless steel is readily corroded by brine.
c. Stainless steel tubing cannot be welded securely to the shaft. Contraction and expansion caused by heating and cooling cream cause joints to break.

Inconel, made by the International Nickel Company, may be welded satisfactorily, and is very resistant to brines. It is entirely suitable for coils but is very expensive. The coil alone costs as much as the entire vat. It consists of 80 per cent nickel, 12 to 14 per cent chromium, and 6 to 8 per cent iron.

Care of Vats (From an Equipment Company). The care of vats is important. To assist in preventing dark spots from appearing on the tinned copper surface of new equipment, these instructions should be followed:

Rinse immediately following the day's run, wash clean with a weak alkali solution; then rinse and sterilize with live steam and wipe dry at once, while still hot, with a clean soft cloth.

Keep all inside surfaces dry until the next time the machine is used.

Continue this method of cleaning and drying for the first two weeks of operation.

Never throw dry washing powder into the machine. Always dissolve it in water first. Be sure to rinse out and sterilize the machine with live steam every day before using.

In operating coil machines never permit hot water to flow through or remain in the coil after the machine is drained of its contents, as this will dry the casein onto the coil, causing a cloudy appearance.

Newly tinned equipment must be washed several times with a mild washing powder, followed by two or three washings in sweet skim milk. This should remove metallic odors, solder flux, etc., which are certain to produce metallic flavor in the cream if not removed. New vats should receive similar treatment before use. Be sure to keep thermometer bulbs in good repair. This is a factory job which cannot be done by local workmen. Bare copper bulbs may be the source of metallic flavor in butter. It is common practice to hold pasteurized cream in vats overnight. This longer holding period may constitute a menace to butter quality unless vats are kept well tinned and stuffing boxes well cared for. Cream must be cooled below churning temperature for long holding periods. Negligence here may be the cause of considerable financial loss in marketing a lower grade of butter.

A vat should be frequently steamed after washing. Put the lids down and raise the temperature in the vat to 180° F. or more. Such heating will cause the vat to dry quite thoroughly when the lids are raised and will inhibit corrosion.

Glass-Lined Equipment. Glass-lined or glazed vats are excellent containers for milk and cream. They are not affected by dairy products, and they do not impart flavor to them. They are excellent storage vats. They are scarcely affected by dilute acids and alkali washing powders except those containing abrasives. However, they do have these minor handicaps:

1. Relatively slow conduction of heat.
2. Jackets susceptible to brine corrosion. Glazing is on iron base and brine slowly corrodes iron.

3. Chipping of glazed surface in open vats owing to careless dropping of tools, etc. (Repairs are possible.)

Surfaces on glass-lined vats are best compared to the glazing on bath tubs and lavatories. These, however, are prepared on both metal and earthenware bases, whereas dairy vat glazings are prepared on iron bases.

Thermometers. Thermometers are of two general types, recording and non-recording. The recording thermometer is being used quite extensively, and the costs have been reduced materially. They furnish the plant superintendent with exact records of the processing of each batch of cream or milk. Plant employees are automatically placed in a position to carry out orders carefully. Short cutting and carelessness are largely eliminated. Recording-thermometer charts are required by law in some states in order that compulsory pasteurization laws may be effectively enforced.

The non-recording thermometers are:

1. Common, inexpensive, glass, floating.
2. Short and long metal stem—straight or angle construction.
3. Mercury activated flexible stem dial type.

Each has its particular uses and adaptabilities. All metal thermometers are now furnished in stainless steel, which is in keeping with the use of these alloys in vats, etc.

All dairy plants should have at least one very accurate thermometer held in reserve to be used as a check on all thermometers in use in the plant. Thermometers are not infallible, and the efficient plant operator must know the accuracy of all thermometers in use. Modern processing methods specify either exact or very narrow temperature ranges. Faulty processing due to inaccurate thermometers is to be scrupulously avoided.

Stuffing Boxes on Vats and Churns. Conventional types of churns and vats have stuffing boxes for rolls and coils. Earlier types of machines were less satisfactory because these boxes were made with less precision and less consideration from the standpoint of sanitation. Boxes on modern equipment are more carefully made and are more easily packed and repaired because of greater accessibility. Housings, guards, and guides have been eliminated or simplified wherever possible, and manufacturers furnish instruc-

DEPRECIATION RATES OF DAIRY PLANT EQUIPMENT

	RATE %	YEARS OF SERVICE
Buildings		
Frame	5	20
Brick-frame	3	33
Stone, concrete block, tile	3	33
Office Fixtures	8	12
Office Furniture		
Safes	5	20
Furniture	10	10
Office machines	12	8
Power Machinery and Equipment		
Boilers and settings	8	12
Steel stack and breaching	14	7
Pumping machinery	10	10
Feed water heaters	10	10
Steam engines	8	12
Gas and oil engines	15	7
Generators	10	10
Motors direct connected	14	7
All other motors	10	10
Electric wiring	10	10
Steam piping	10	10
Water lines	10	10
Shafting and pulleys	8	12
Belting	25	4
Refrigerating Machines	8	12
Butter Machinery and Equipment		
Churns	10	10
Cream vats	12	8
Scales	20	5
Weighing cans	20	5
Can washers	15	7
Sanitary pipe	20	5
Pumps	15	7
Milk Driers	10	10

tions on proper care of these parts to promote more years of service as well as to encourage efforts to maintain sanitary conditions.

There is need for very special emphasis on the care of stuffing boxes. Always keep plenty of packing on hand and repack frequently. Tighten the packing gland gradually for several days in order that the new packing becomes sufficiently compressed to avoid leaks and undue friction and wear may be avoided. Neglect in the care of these boxes may result in insanitary conditions. Use only the packing provided by the manufacturer of the equipment and consult him about its application.

Depreciation of Creamery Equipment. Only average figures can be given on the life of creamery equipment. There is much less difference in the life of various makes of equipment than there is in the care given them in operation. See page 326 for depreciation rates given by W. F. Jensen,[2] formerly secretary of the American Association of Creamery Butter Manufacturers.

QUESTIONS

1. What metals have long been used for dairy equipment, particularly vats, ripeners, starter cans, etc.?
2. State the advantages of copper as a base for plated metals.
3. What unplated metals are used? What factors prevent their general use?
4. State the advantages and disadvantages of the use of glass-lined vats.
5. Describe some alloys used in making dairy equipment.
6. Give the composition of stainless steel, and state its advantages and disadvantages.
7. Compare aluminum and stainless steel in their resistance to corrosion by washing powders.
8. Who makes use of recording thermometer charts after their use by plant operators?
9. Discuss the care of stuffing boxes on vats and churns.
10. What is the average life of churns and cream vats?
11. Discuss the preparation of new or retinned cream vats before use.

REFERENCES

1. Hunziker, O. H., W. A. Cordes, and B. H. Nissen, "Metals in Dairy Equipment," *J. Dairy Sci.*, Vol. 12, p. 140, 1929.
2. Jensen, W. F., "Comment on Creamery Matters," *Am. Creamery and Poultry Produce Rev.*, Vol. 73, p. 740, 1932.

CHAPTER 16

REFRIGERATION

Many creameries formerly used ice for refrigeration. Labor cost less then, and mechanical refrigerating equipment and installations were comparatively expensive. Mechanical refrigeration has been greatly improved, and equipment is manufactured and sold in such quantities that costs are greatly reduced. Temperatures maintained are much lower than was possible with ice. The convenience and savings in labor are much in favor of mechanical refrigeration. Very few creameries today depend upon natural ice. Costs of ice as compared with mechanical refrigeration are now definitely in favor of the latter.

Shift to Mechanical Refrigeration. A 5-ton compressor and installation will cost less than $2000. The annual cost of ice will be about $500. These costs have reference to a creamery making about 300,000 pounds of butter per year. Savings in ice costs for 4 years, therefore, will about pay for the installation of mechanical refrigeration.

Guthrie[1] has stated that in 1924, in Minnesota, he found 54 creameries storing their own ice, 12 bought ice daily, and 19 had ice machines. These data are definitely obsolete now, owing to the lower costs of equipment and convenience of operation, as well as saving in labor. It may be safely estimated that less than 10 per cent of creameries now operate with ice.

Evaporation of a volatile (low boiling point) liquid like ether produces cooling, thus illustrating one principle of refrigeration. In Fig. 94 the large evaporating surface in *B* produces additional refrigeration and in proportion to the surface exposed.

Gases Used in Refrigeration. Ammonia, carbon dioxide, and sulphur dioxide have long been used for refrigeration. More recently methyl chloride, ethyl chloride, and some other gases requiring lower operating pressures have been used on such small units as household refrigerators, ice-cream cabinets, etc. Ammonia is outstanding in its suitability for use in dairy-plant operation. It operates with medium temperatures and pressures. It does not require such large-capacity compressors as sulphur dioxide, for example,

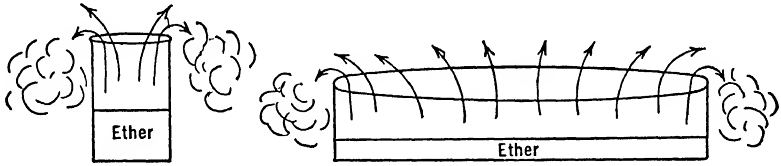

FIG. 94. Demonstration of one of the principles of refrigeration—increased evaporation surface.

and on the other hand does not operate with the excessively high pressures required for carbon dioxide. It has other properties which are very desirable. It can be used with ordinary iron pipes, fittings, etc., and will not cause corrosion. Tiny leaks are easily noticed by smell and nose irritation. It is not poisonous as is carbon dioxide. The following table gives some comparison of the various gases.

PROPERTIES OF GASES USED FOR REFRIGERATION

Gas	Chemical symbol	Boiling point at atmospheric pressure	Total heat of vapor	Total heat of liquid	Pressure pounds per square inch absolute		Theoretical capacity; given size compressor used with different refrigerants
Degrees F.......	......	....	5° F.	86° F.	5° F.	86° F.	....
Ammonia........	NH_3	−28.0° F.	613.3	138.9	33.7	170.2	5 ton with NH_3
Carbon dioxide...	CO_2	−110.0° F.	138.0	83.3	334.2	1039.0	20 tons with CO_2
Sulphur dioxide..	SO_2	−14.5° F.	183.5	42.1	11.8	66.4	1 ton with SO_2
Methyl chloride..	CH_3 Cl	+54.5° F.	195.2	44.0	20.9	97.5	....
Ethyl chloride...	C_2H_5 Cl	−10.0° F.	165.4	23.0	−10.0	−12.4	....

Comparison of Various Gases Used in Refrigeration. Note large heat of vaporization of ammonia, which means more cooling power per unit volume. Note high operating pressures for carbon

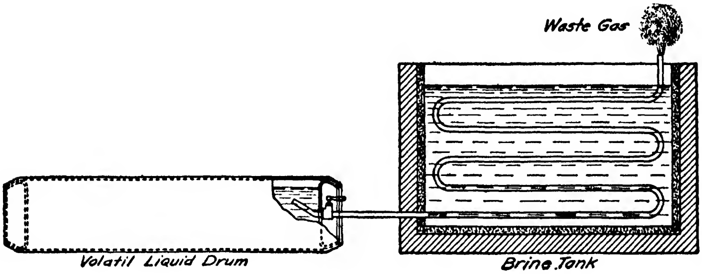

FIG. 95. A simple refrigeration system. Commercially impractical; gas must be reclaimed and used again. Courtesy J. T. Bowen, "Dairy Engineering," John Wiley & Sons, Inc.

dioxide, which necessitate great expense to make a machine and piping which will retain the gas.

Total heat of vapor less total heat of liquid equals the refrigerat-

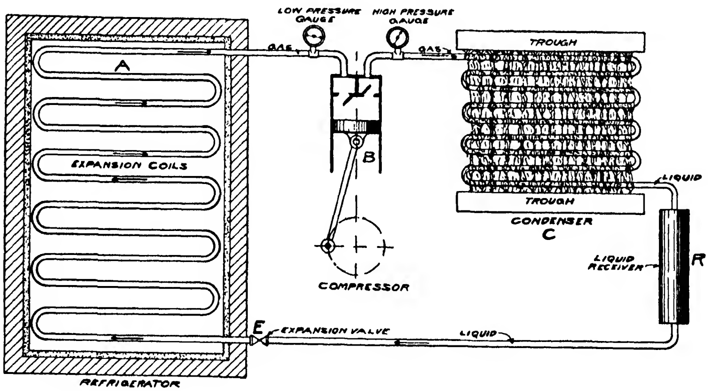

FIG. 96. Simple direct expansion system. Courtesy J. T. Bowen, "Dairy Engineering," John Wiley & Sons, Inc.

ing effect, i.e., in passing from the liquid to the gaseous stage heat units are required. The greater the difference, the more efficient is the refrigerant in this respect. (Other considerations are also important.) It will be noted that ammonia has three times the

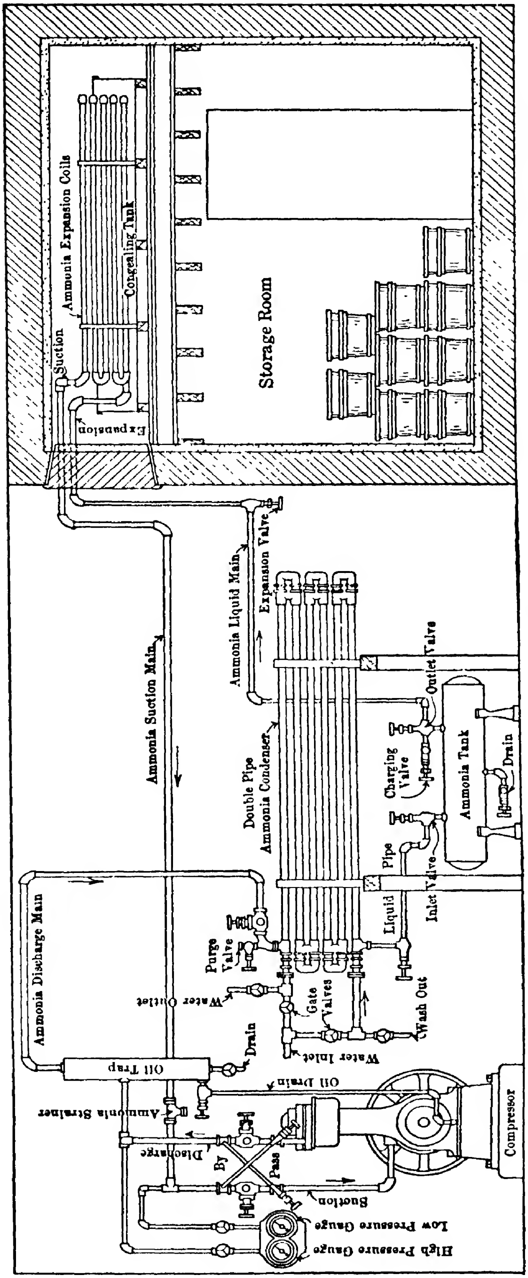

FIG. 97. Complete compression refrigerating installation. Courtesy J. T. Bowen, "Dairy Engineering," John Wiley & Sons, Inc.

refrigerating effect of methyl chloride, which is next best in this respect.

It should be noted that methyl chloride has a boiling point of

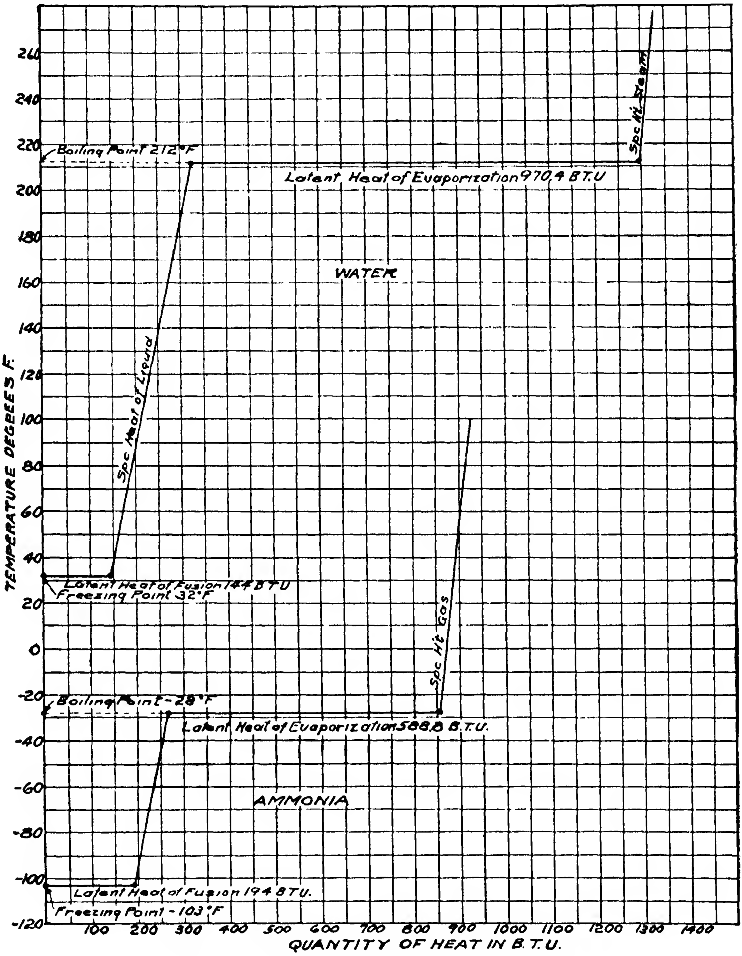

FIG. 98. Comparison of the heat content of a pound of water and a pound of ammonia at atmospheric temperature. Courtesy J. T. Bowen, "Dairy Engineering," John Wiley & Sons, Inc.

54.5° F., which is relatively high. It is very suitable for installations not requiring temperatures below zero.

Reclaiming Gas: Purpose of Compressor. If ammonia gas were exceedingly cheap, it might be used to produce refrigeration and be allowed to escape into the open air. Such a refrigerating installation would be relatively simple and no compressor would be needed. For three very good reasons we install a compressor which enables us to use the same gas continuously in the cycle. We reclaim the gas and do not waste it, because:

1. It is not cheap (about 20 cents per pound).
2. Its vapors would create a public nuisance and destroy plant life.
3. To avoid frequent replacement of drums to supply ammonia.

Cycle of Refrigeration. The cycle of refrigerating gas is:

1. Compression.
2. Condensation and liquefaction.
3. Expansion.

Compression. The compressor must receive *gas* from the low-pressure or return line. *Liquids* can be compressed only slightly. This is why we have pet cocks on steam-engine cylinders. Water which gets into the cylinder produces "slapping" and may burst the cylinder. Compressors do not have pet cocks, but modern ice machines do have spring valve heads which act as safety valves if much liquid ammonia enters. When a compressor stands idle a few hours, back pressure builds up; and, when the machine starts, some liquid ammonia may enter the cylinders. This produces some "slapping" for a few minutes after the machine is started. The slapping soon subsides, and the operation becomes smooth.

Condensation and Liquefaction. The gas, when compressed, gets hot. It is conducted to the condenser coils, where cold water circulation causes it to turn to liquid ammonia. It then passes by gravity to the ammonia receiver. The cold water not only produces condensation and liquefaction but also removes the heat from the ammonia, cooling it to near the temperature of the cooling water. The efficiency of cooling depends on the amount of coil surface in the condenser, the amount of scale which it has accumulated, and the temperature and rate of flow of the water used. It is important that plenty of condenser capacity be used and that the water pipes be kept clean and free from sediment and scale. In the southern states, where water may have higher temperatures, more condenser capacity should be provided.

Expansion. The liquid ammonia from the receiver is conducted to the expansion valve or master valve. This valve is opened one-fourth to one-half turn, when operating conditions are normal and with sufficient gas in the system. The liquid ammonia must be fed slowly to the coils in the refrigerator. Feeding too fast reduces the difference between the low and the high pressure sides and reduces heat removal from the ammonia. Feeding too slowly reduces the low or suction pressure so that the machine tends to starve and not to perform efficiently. Maintenance of proper operating pressures is very important. It reduces the number of operating hours and saves water and power bills. Operation with a back pressure of 25 pounds will produce economical results and will also produce sufficiently low, room, and brine temperatures for creamery work. With such a back pressure, more ammonia gas is compressed at each stroke of the piston because the gas is denser. (NOTE: Low pressure, back pressure, suction pressure are synonymous.)

Modern Multiple-Feed Heads. A rather recent development in conducting the ammonia gas through the expansion system in the refrigerating chambers is a multiple-head feed. Instead of conducting the ammonia through one feed and through great lengths of coils, the newer method consists of feeding into a head which has numerous direct outlets into the coils. This permits of more rapid circulation of the ammonia and provides ammonia-wet inside surfaces. These wet surfaces cause much more rapid vaporization of the wet ammonia, hence much more rapid cooling with a given amount of coil surface. Savings of at least one-third in operating costs have been reported. Not only are new installations of this type used, but also many old installations are being revamped.

Brines. Calcium chloride is very largely used in making brine. Sodium chloride or common salt has also been used, but it is more corrosive and more salt is required to produce a given freezing point. Sodium chloride of a suitable grade costs about 1 cent per pound, and calcium chloride costs nearly 3 cents per pound.

Brine serves as a storage medium for refrigeration. It serves also as a convenient method of transferring refrigeration to various pieces of equipment in the plant. An ice box containing a brine tank will continue to refrigerate for many hours in case of trouble and stops with the compressor.

There is, however, a definite trend to the use of direct-expansion cooling systems. Open-air coolers for milk and cream are carrying ammonia now instead of brine. Ice-cream freezers are using ammonia direct, instead of brine. Direct-expansion cooling is more economical after it is installed. The first cost of installation is higher. Open-air coils for cooling milk and cream must be made

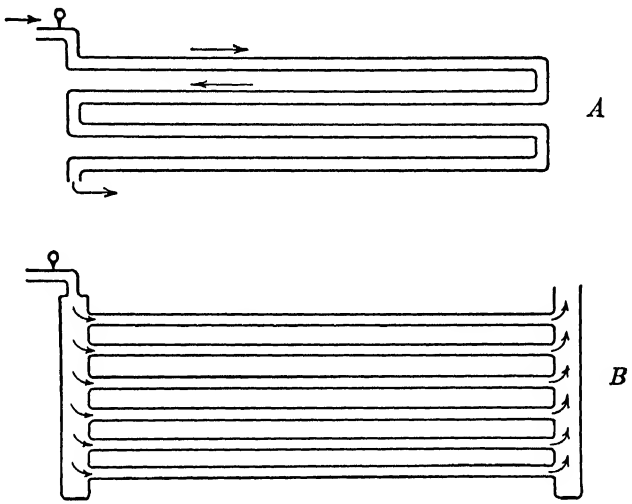

FIG. 99. Comparison of the "old" and "new" methods of feeding ammonia through evaporation coils in the refrigerator.

A. Old Method—Single-Coil Feed.

B. Modern Multiple-Feed Head. Internal surface of pipe is wet with liquid ammonia. More rapid evaporation increases the rate of cooling and greater efficiency results.

of stainless steel, as copper and brass are promptly decomposed by ammonia.

Location of Brine Tanks. Brine tanks have been located in the refrigerating rooms. As previously stated, the reserve refrigeration serves well in case of trouble and the brine helps cool the room. Coolers, however, must have rather high ceilings to provide room for the tank. This extra space must be refrigerated, and cooling costs increase. Brine tanks are now being located somewhere outside the cooler. Some are placed in the basement; where there are no basements some are placed outside the building. The north side of a building is naturally most suitable. These tanks can be buried in the ground or can be built on the surface. In either case, they should be well insulated. Either basement tanks or outside tanks have the advantage of easy accessibility for repair or caring for brine. These tanks may be built of cement and will have longer life than metal or wood tanks installed in the coolers. Cement tanks should be coated with asphalt paint as calcium chloride, in particular, slowly deteriorates cement.

The tables appearing below give the properties of brines of different concentrations.

Sodium Chloride (Salt) Solution

(From John T. Bowen, *Dairy Engineering*, p. 413, John Wiley & Sons. Courtesy of the author and the publisher.)

Specific Gravity at 39° F.	Degrees Baumé at 60° F.	Degrees Salometer at 60° F.	Pounds of Salt per Gallon of Solution	Pounds of Salt per Cu. Ft.	Percentage of Salt by Weight	Freezing-point Farenheit	Specific Heat	Weight per Gallon at 39° F.
1.007	1	4	0.084	0.628	1	31.8	0.992	8.40
1.015	2	8	0.169	1.264	2	29.3	0.984	8 46
1.023	3	12	0.256	1.914	3	27.8	0.976	8.53
1.030	4	16	0.344	2.573	4	26.6	0.968	8.59
1.037	5	20	0.433	3.238	5	25.2	0.960	8.65
1.045	6	24	0.523	3.912	6	23.9	0.946	8.72
1.053	7	28	0.617	4.615	7	22.5	0.932	8.78
1.061	8	32	0.708	5.295	8	21.2	0.919	8.85
1.068	9	36	0.802	5.998	9	19.9	0.905	8.91
1.076	10	40	0.897	6.709	10	18.7	0.892	8.97
1.091	12	48	1.092	8.168	12	16.0	0.874	9.10
1.115	15	60	1.389	10.389	15	12.2	0.855	9.26
1.155	20	80	1.928	14.421	20	6.1	0.829	9.64
1.187	24	96	2.376	17.772	24	1.2	0.795	9.90
1.196	25	100	2.488	18.610	25	0.5	0.783	9.97
1.204	26	104	2.610	19.522	26	−1.1	0.771	10.04

Scheme of Heat Transfer. To avoid having the student confused as to the final accomplishments of refrigeration, let us explain very simply the scheme of heat transfer in mechanical refrigeration. Gaseous ammonia is compressed. Compression raises the temperature of ammonia as it does any gas. (Compression of air, in a bicycle pump, makes the air and the pump warm.) Water flows through an internal pipe in the condensers and takes excess heat

Calcium Chloride Solution

(From John T. Bowen, *Dairy Engineering*, p. 414, John Wiley & Sons. Courtesy of the author and the publisher.)

Degrees Baumé 60° F.	Specific Gravity 60° F.	Degrees Salometer 60° F.	% $CaCl_2$ by Weight	Pounds $CaCl_2$ per Gallon of Solution (Approx.)	Freezing Point ° F.	Specific Heat
0	1.000	0	0	0	+32.	1.00
1.	1.007	4	1	....	31.1	0.99
2.1	1.015	8	2	....	30.4	0.97
3.4	1.024	12	3	½	29.5	0.96
4.5	1.032	16	4	....	28.6	0.94
5.7	1.041	22	5	....	27.7	0.93
6.8	1.049	26	6	1	26.6	0.91
8.	1.058	32	7	....	25.5	0.90
9.1	1.067	36	8	....	24.3	0.88
10.2	1.076	40	9	1½	22.8	0.87
11.4	1.085	44	10	....	21.3	0.86
12.5	1.094	48	11	....	19.7	0.84
13.5	1.103	52	12	2	18.1	0.83
14.6	1.112	58	13	....	16.3	0.82
15.6	1.121	62	14	....	14.3	0.815
16.8	1.131	68	15	2½	12.2	0.795
17.8	1.140	72	16	....	10.	0.78
19	1.151	76	17	....	7.5	0.77
20	1.160	80	18	3	4.6	0.755
21	1.160	84	19	....	+ 1.7	0.74
22	1.179	88	20	....	− 1.4	0.73
23	1.188	92	21	3½	4.9	0.72
24	1.198	96	22	....	8.6	0.71
25	1.208	100	23	....	11.6	0.70
26	1.218	104	24	4	17.1	0.69
27	1.229	108	25	....	21.8	0.685
28	1.239	112	26	....	27.	0.68
29	1.250	116	27	4½	32.6	0.67
30	1.261	120	28	....	39.2	0.665
31	1.272	124	29	....	46.2	0.66
32	1.283	128	30	5	−54.4	0.65

from the ammonia. The ammonia is then conducted to the coolers. It is released from high to low pressure and evaporates rapidly. Evaporation cools, and the temperature of the ammonia drops sharply. It cools the coils, which in turn cool the air of the cooler or the brine in which coils are immersed. Thus the ammonia gets back the heat taken out by the water at the condensers. As it returns to the compresser it is compressed, heats, and again loses this heat to the water in the condenser coils. Thus the cycle proceeds.

Ammonia boils at 28° F. below zero, under atmospheric pressure, and it also evaporates rapidly under low pressure in cold coils.

Water for the condenser should increase at least 8° F. in temperature as it passes through the coils. Less difference in temperature indicates waste of water unless relatively warm cooling water enters the condensers.

Building Coolers or Storage Rooms. There has been some tendency the past few years toward individual and local plans for building coolers. This may be feasible in some instances, where serious financial difficulties exist. On the whole, it is poor practice and false economy because poorly insulated rooms will not maintain low temperatures. Extra costs of water and electric power necessarily increase operating expense. This money should go to building a better room. Higher, cooler temperatures, especially during warm weather, may jeopardize the quality of butter stored.

The plans of refrigerating engineers are based on knowledge and experience. Their installations are permanent, are figured on peak summer and volume demands, and are definitely more satisfactory. For this reason we shall not discuss insulating materials, sizes of coolers, and their construction.

Forced Air Cooling. Many present-day installations in ice boxes include forced-air circulation. The evaporating coils may contain either pump-circulated brine or may carry ammonia. An electric fan placed in the coil container forces a rapid circulation of air, and the rate of cooling may be increased several times. With well-constructed and well-drained floors, this air circulation keeps the floors dry.

A clearer conception of this method of cooling ice boxes might be gained by comparing it with modern methods of heating large rooms, such as stores, theatres, creameries, etc. Radiators of the automobile type are placed in elevated, open spaces, and low-pressure steam heat is blown from the radiator by means of an electric fan. A small radiator will heat a large room, with less cost. The old method of depending upon circulation by convection is more expensive and less satisfactory.

Tests for Ammonia Leaks. Expansion coils in refrigerators are usually installed as:

1. So-called, open-air coils.
2. Immersed in brine, either in tubes or tanks.

Leaks in open-air coils are usually quite easily located. Ammonia gas escaping from a leak is very promptly noticeable. Exceedingly small leaks emit enough gas so that the sense of smell is affected.

Sulphur strings or phenolphthalein-treated paper are most commonly used to locate leaks. The sulphur string is lighted, and the burning sulphur produces SO_2. The SO_2 is a colorless gas until it comes in contact with ammonia, when dense white fumes are formed. If the air contains considerable ammonia, a fan may be used to clear the air partially so that leaks may be more easily located.

Phenolphthalein indicator used to make acidity tests may be dropped on a strip of white paper. When placed near an ammonia leak, the paper promptly turns pink. Ammonia readily combines with water on the wet paper, forming ammonium hydroxide, and as such has basic or alkaline properties. Such strips of paper should be prepared at leisure, allowed to dry, and kept ready for use. When needed, wet the strip with tap water and proceed.

A less practical means of locating ammonia leaks is by the use of hydrochloric acid, sufficiently concentrated to give off hydrochloric-acid gas. The contact of the acid fumes and ammonia fumes causes dense white clouds of ammonium chloride.

Ammonia Leaks in Brine. When brine-immersed coils develop leaks, a more difficult problem arises. Tests may be made on the brine to determine if it contains ammonia. A sample of brine may be placed in a test tube, and a few cubic centimeters of Nessler's reagent poured carefully down the side of the tube. A yellowish brown ring appears at the interface between the liquids if much ammonia is present. If the leak is rather large, its presence may be established by the crackling sound which ammonia makes as it comes in contact with the brine. Gas bubbles may not float to the surface until much ammonia has combined with the brine, because of the affinity of ammonia for water. If the brine contains ammonia, it must be pumped out and the leak can then be located definitely.

Care of Equipment. *Care of Brine.* The following points must be considered in properly caring for brine.

1. Avoid dilution.
2. Prevent splashing in brine tanks.
3. Maintain sufficient concentration to avoid slush formation; this may impede brine circulation.
4. Keep ammonia coils covered with brine. (Prevents rusting.)
5. Keep brine neutral or slightly alkaline.

Some careless operators allow water to pass through cooling coils and to be pumped back with the brine. Shortly the brine is too weak to stand the accustomed temperatures and slushing results. Impeded brine circulation may seriously delay operations.

Brine return lines should be installed so that the brine enters near the bottom of the tank. If brine splashes as it returns into the tank, it tends to hasten corrosion of bare ammonia pipes, because air is incorporated with the brine. The carbon dioxide of the air slowly produces a trace of acidity, and the rate of corrosion of the entire brine circulating system is greater.

Frequent checks for acidity in brine should be made. Add a few drops of phenolphthalein indicator (common acidity test indicator) to 17.6 cubic centimeters of the brine. If a faint pink color appears, the brine needs no attention, as it is faintly alkaline. If no pink color is observed, add a drop or two of $N/10$ sodium hydroxide to the test sample. If no faint pink color develops, the brine needs to be treated with alkali to correct a slight acid condition. Soda ash, dissolved in water, may be added at the rate of 1 pound to 200 gallons of brine. Retest the brine after a day or two to determine its condition.

Calcium hydrate, or milk of lime, may be used to correct brine acidity. A sack containing a few pounds of lime may be hung over the side of the brine tank, and, even though an excess of lime is used, it will not produce an alkaline condition in the brine because lime has low solubility.

Care of the Compressor and Condenser Coils. The creamery operator should observe the condition of the compressor and engage the services of a reliable mechanic to repair and service it. Such repairing and reconditioning should not be attempted by the plant personnel. The greatest service to be given the compressor is using the proper kind of oil. "Just as good" oils should not be used. Oil recommended by the manufacturer of the machine should be bought.

High operating pressures are usually avoidable if a proper installation is made. Condenser coils may become coated with rust and water hardness. If this is not removed periodically, inefficient condensing of ammonia results and operating pressures are higher. This not only increases power costs, but is also not good for the compressor. Excessive pressure generates more heat and increases the wear on the pistons and cylinders.

Remove the caps on the condenser coils and clean the water tubes with a wire brush. Mechanical cleaning with a brush may be required less frequently if a solution of caustic soda is flushed through the coils occasionally. This softens lime deposits and tends to facilitate cleaning.

Purging the System. After a few months operation, there may be a slight accumulation of air in the system. Undetectable leaks may occur and air may enter. Each installation is equipped with an air-purge valve. After the machine has been standing idle for a few hours, as in the morning, open the purge valve and allow enough gas to pass out so there is reasonable assurance that any air in the system has been removed. Follow directions given in the instruction manual. One method of purging consists of passing the purged gases into water. The purge valve is opened about one-fourth turn, and the gases released slowly. Air passing through water escapes at the surface. As soon as much ammonia enters the water, a sharp crackling sound is made.

Failure to remove air causes higher operating pressures. Air does not turn to a liquid and, therefore, occupies too much space. Air can be liquefied only under extremely high pressures and exceedingly low temperatures. It might be used in a refrigerating system if this were not so.

Purging Oil. Some oil from the crankshaft of the compressor follows the ammonia as it passes to the high side of the system. This oil settles in the oil trap, where it should be drained occasionally. Many operators do not drain often enough, and oil may pass through the condenser coils and eventually get over into the cooling coils in the refrigerator. This is a serious mistake. Oil in the condenser tends to insulate, and higher operating pressures and greater power costs are the result. Oil in the cooling coils of the refrigerator retards evaporation and cooling. An instance is cited where it was necessary to disconnect the cooling coils and flush them with steam. A surprising amount of oil and debris were removed. The efficiency of this installation was thus greatly improved.

There are many other details to consider in efficient operation of mechanical refrigerators. Proper care increases the efficiency of operation and prolongs the life of refrigerating equipment. The operator is strongly urged to study instruction books, and to use the service and advice obtainable from representatives of the manufacturers of refrigerating equipment.

How to Compute Necessary Refrigerating Equipment for a Creamery Manufacturing Butter Only and Using Coil-Type Ripeners. The following figures are based not on purely scientific facts or tables but rather on engineering calculations which have been satisfactorily worked out and proved by test and use.

Note A: For convenience and safety it is assumed that cream has a specific heat of 1.0, the same as water. It is advisable to use this figure because the butterfat in cream varies in different creameries and even varies from day to day in the same creamery.

Note B: In figuring the amount of brine needed, it is advisable to use 7 B.t.u.'s * per gallon per degree Fahrenheit temperature rise. This figure is a safe factor whether calcium chloride brine or sodium chloride brine (salt brine) is used, and it also allows for the variance of brine densities which may be used in cream-cooling work.

Note C: In figuring the number of gallons of brine per cubic foot content of brine tank, it is advisable to allow 7.5 gallons per cubic foot. This permits brine-tank coil displacement and allows for brine level a few inches below top of tank.

Total B.t.u.'s to Be Extracted from Cream After Cooling with Water. The first step in computing the refrigerating equipment is to make calculations of the total number of B.t.u.'s that must be

* B.t.u.: British Thermal Unit—amount of heat required to raise one pound of water through one degree temperature Fahrenheit.

extracted from the maximum amount of cream to be cooled in one day during the flush season. This is done by multiplying the pounds of cream by the specific heat of cream by the difference in temperature of the cream before and after brine cooling.

Equation I

$$X = A \times B \times C$$

Where

$X =$ Total B.t.u.'s to be taken from cream by brine cooling
$A =$ Pounds of cream
$B =$ Specific heat of cream (1.0). (See Note A.)
$C =$ Number of degrees difference in temperature of cream before and after brine cooling.

Total B.t.u.'s That May Be Extracted by Brine Storage. The next step is to estimate the size of brine tank required. Base this calculation on 1 to 1.5 gallons of brine per gallon of cream to be cooled. Use 1.5 if the room available will permit tank of this size.

When the tank capacity has been determined, calculations may be made for the total B.t.u.'s that can be extracted from the cream by the brine during a 10 to 15° rise in temperature of the brine; this difference in temperature takes place from the time the first vat of cream has started to cool by brine until the last vat has been finished. This is done by multiplying the number of gallons of brine by 7.5 by the temperature rise of brine allowed. (Temperature rise from 10 to 15°.)

Equation II

$$X = (D \times 7) \times 7.5 \times E$$

Where $X =$ Total B.t.u.'s taken up by brine storage
$D =$ Cubic feet content of brine tank
$7 =$ Constant (See Note B.)
$7.5 =$ Constant (See Note C.)
$E =$ Number degrees temperature rise in brine during entire cream-cooling period

Size of Refrigerating Machine Required. Equation I gave us the total number of B.t.u.'s that must be extracted from the cream; Equation II the number of B.t.u.'s extracted by brine stored in tank. Now if we subtract the number of B.t.u.'s of Equation II from the B.t.u.'s of Equation I, we shall have the number of B.t.u.'s that must be extracted by the refrigerating machine, through the brine tank coils, during the time allowed for cream cooling.

The time allowed for cooling is very important, and has much to do with the size of the brine tank and size of machine required, so it must be definitely understood what time is required from the starting of the first vat of cream until the last vat of cream is cooled to the proper temperature. This time element varies greatly in creameries manufacturing the same amount of butter per year. One creamery may use trucks and collect its cream; these trucks start out together and return within a few hours of each other. In such a creamery, the cooling may be done in a short time. In another creamery, where patrons bring in cream only three days a week, the cooling spreads over a longer time. In a third creamery, where patrons may bring cream to the door any time any day, the cooling period is still longer.

Equation III

$$X = \frac{\text{Equation I} - \text{Equation II}}{F \times 12{,}000}$$

Where

X = Minimum tons of machine capacity required

F = Number of hours required from time cream cooling with brine is started until it is finished

12,00 = Constant—number of B.t.u.'s per hour per ton of refrigeration

Number of Feet of Brine Tank Coils Required. In creameries where the brine tank or tanks are inside the butter cooler, it is advisable to put a sufficient amount of coils in the brine tanks to produce the same refrigerating capacity as that of the machine.

For practical purposes it is well to estimate that the machine will operate at 15.7 pounds suction pressure or 0° F. when the brine temperature is at 14° F. and 25 pounds suction pressure, or 11.3° F. when the brine temperature is at 25° F. (14° F. being the temperature of brine when cream cooling is begun and 25° F. the temperature at end of cooling period).

Equation IV

$$X = \frac{G \times 12{,}000 \times 2.3.}{12.5 \times (H - I)}$$

Where

$X =$ Number of linear feet of 1¼ inch coils
$G =$ Tons refrigeration per hour required
$12{,}000 =$ Constant — B.t.u.'s per ton refrigeration
$12.5 =$ B.t.u.'s transmission for 1 square foot of surface per 1° temperature difference
$2.3 =$ Number of linear feet of 1¼ inch pipe per 1 square foot of surface
$H =$ Average temperature of brine during cream-cooling period
$I =$ Average temperature of ammonia inside brine tank coils during cream-cooling period.

Example. Consider a creamery which manufactures 300,000 to 500,000 pounds of butter annually and has three 300-gallon (2400 pounds) coil type ripeners or vats and a 1000-pound butter churn. Maximum daily load is three full vats and the cream must be cooled from 80 to 45° in 3 hours.

Use Equation I to get the total B.t.u.'s to be extracted from the cream.

$$\begin{aligned} X &= A \times B \times C \\ &= (3 \times 2400) \times 1.0 \times (80 - 45) \\ &= 252{,}000 \text{ — number of B.t.u.'s} \end{aligned}$$

It is assumed that a brine tank 14 feet long by 3 feet wide by 3½ feet high can be placed inside the butter cooler, Equation II becomes:

$$\begin{aligned} X &= (D \times 7) \times 7.5 \times E \\ &= ([14 \times 3 \times 3\tfrac{1}{2}] \times 7) \times 7.5 \times 11^\circ \\ &= 84{,}893 \text{ — number of B.t.u.'s that may be extracted by brine storage.} \end{aligned}$$

From Equation III:

$$\begin{aligned} X &= \frac{\text{Equation I} - \text{Equation II}}{F \times 12{,}000} \\ &= \frac{252{,}000 - 84{,}893}{3 \times 12{,}000} \\ &= 4.64 \text{ — minimum number of tons refrigerating machine required} \end{aligned}$$

From Equation IV:

$$X = \frac{G \times 12{,}000 \times 2.3}{12.5 \times (H - I)}$$

$$= \frac{4.64 \times 12{,}000 \times 2.3}{12.5 \times \left(\frac{14 + 25}{2} - \frac{O + 11.3}{2} \right)}$$

= 740 — number of feet of 1¼-inch piping required to produce 4.64 tons refrigeration.

In addition to the above refrigeration, the butter from the churn must be cooled to holding temperature and the butter cooler must be kept at 40 to 45° (colder for unsalted butter). The machine capacity considered is sufficient to care for this additional load, for it may be done before or after the cream-cooling period.

QUESTIONS

1. Why do ether, alcohol, or gasoline produce more rapid cooling than water when dropped on the skin?
2. Name three gases used in mechanical refrigeration. Discuss their suitabilities and adaptabilities.
3. Name the two factors which cause ammonia gas to turn to liquid ammonia in the condenser coils.
4. Draw diagram of a mechanical refrigeration system, indicating where the ammonia is (*a*) a gas, (*b*) a liquid.
5. What may be the causes of excessive operating pressures?
6. Explain by diagram and discussion the principles involved in the operation of multiple-feed heads in evaporating systems.
7. Explain the scheme of heat transfer in refrigeration. Trace the route of the heat in its removal.
8. Could air be used as a refrigerant?
9. Why should air and oil be purged frequently?

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CHAPTER 17

WASHING POWDERS

Basic Chemicals of Washing Powders. The principal effective cleaning and emulsifying agents used in washing powders are:

Common Name	Approximate Cost per 100 pounds
1. Soda ash	$2.50
2. Bicarbonate of soda	3.00
3. Caustic soda	5.00
4. Trisodium phosphate	5.00
5. Sodium metasilicate	5.00
6. Borax	——
7. Soap	——

Commercial Powders. These chemicals can be bought as such, or they can be bought in the form of commercial washing powders under various trade names. Commercial brands of powders are of several general types:

1. *Detergents.* These are of low alkalinity, contain volcanic ash or other grit, and serve well where both emulsifying and scouring are desired, as on paint, milk stone removal, etc.

2. *Mild alkali powders.* These usually contain soda ash and sodium bicarbonate. They may contain some volcanic ash or chalk as light scouring agents. They are very suitable for churns, vats, etc.

3. *Caustic base powders.* These usually contain caustic soda and soda ash; they are quite severe and are suitable for bottle washing particularly. Their general use must be handled with judgment and full knowledge of their severity.

4. *Cleansers and emulsors.* These consist of trisodium phosphate or sodium metasilicate. They usually contain some soda ash or neutral soda, may have borax, clean by saponification, solution

of proteins and emulsification or mechanical suspension of foreign material. They are free rinsers, very suitable for glassware, often corrosive on metals.

5. *Washing powders carrying chlorine.* These contain sodium hypochlorite or may contain chloramines, usually more valuable for disinfecting and deodorizing purposes.

Selection of Washing Powders. The use of commercial brands of washing powder is often advisable and very suitable for the operator who does not interest himself in various alkalies and their properties. Manufacturers of commercial powders have in many instances made excellent combinations of different alkalies which are more suitable for special purposes than single alkalies.

For the operator who cares to make a study of the properties and particular uses of various chemicals employed in washing and cleaning, the purchase of alkalies, as such, may be advisable. Considerable economy may result from this practice. Those who use large amounts of washing powders are in the best position to buy the chemicals and prepare them for use according to their own ideas.

The correct type of washing powder to use depends not only upon the purpose for which it is intended but also upon the hardness of the water encountered. The total hardness and the kind of hardness are factors to be considered. Washing powders that are satisfactory in one locality may be unsatisfactory elsewhere. It is advisable to state the degree of hardness of water when buying the various powders.

Washing Powders for Churns. Only washing powders of the mild type should be used in churns. They should not be used daily, as indicated elsewhere under "Churn Care," p. 222. They may actually induce an accumulation of material resembling milk stone, and this is to be avoided. In using these washing powders, the water should not be over 140° F. because higher temperatures tend to facilitate such milk-stone deposits. After using the washing powder solution, empty the churn and follow with hot water at 180° F. or more.

Washing Cream Vats. Cream vats should be washed with the milder or neutral soda types of powders. Always be sure to dissolve the powder before using and do not leave such solutions standing in vats. Wash, rinse, and dry.

Barnum, Lucas, and Hartsuch [1] in 1935 tested sixteen commercial washing powders. Some of their results are tabulated below. The high resistance of chrome-nickel steel, ascoloy, and nickel is noteworthy. The data concerning aluminum should not be misinterpreted; the greatest corrosion was caused by powders 6, 7, and 8, owing to the fact that these were superalkalies, and aluminum

SHOWING APPEARANCE OF CLEANER SOLUTIONS AFTER FOURTEEN DAYS' CONTACT WITH METALS (0.625 PER CENT CONCENTRATIONS)

(From Mich. Special Bull. 262, Barnum, Lucas, Hartsuch, 1935)

Cleaner No.	Aluminum	Copper	Nickel	Tinned Copper	Tinned Steel	Ascoloy	Chrome Nickel Steel
1	....	Green	....	Light Green	Slight White	.....	.....
2	....	Green	....	Light Green	Ppt. Very Light Green	.....	.....
3	....	Green	....	Light Green	Slight White	.....	.....
4	....	Green	....	Light Green	Ppt. Slight White	.....	.....
5	....	Light Green	....	......	Greenish Yellow	.....	.....
6	Heavy White ppt	......	....	......	Slightly Cloudy	.....	.....
7	Heavy White ppt	......	....	......	Slightly Cloudy	.....	.....
8	Heavy White ppt	......	....	......	Slightly Cloudy	.....	.....
9	Light Blue......	......	....	......	Greenish Yellow	.....	.....
10	....	......	....	......	....	.....	.....
11	Slightly Cloudy..	......	....	......	Light Yellow	.....	.....
12	....	......	....	......	Light Yellow	.....	.....
13	....	......	....	......	Light Yellow	.....	.....
14	....	Very Light Blue	....	Light Blue	Light Yellow	.....	.....
15	Slightly Cloudy..	......	....	......	Yellow	.....	.....
16	Medium Cloudy.	Light Green	Slightly Cloudy	......	Slightly Yellow	.....	.....

is admittedly non-resistant to practically all alkalies. Of the sixteen washing powders:

1-4 equals neutral or modified sodas.
5 " soda ash.
6-8 " special alkalies.
9-15 " trisodium phosphate.
16 " colloidal.

Showing Properties of Five General Groups of Washing Powders
(Data Tabulated Left to Right Showing Properties)

(From Mich. Special Bull. 262, Barnum, Lucas, and Hartsuch, 1935)

Least to Greatest

Solubility	Colloidal	Trisodium phosphate	Special Alkalies	Neutral Soda	Soda Ash
Causticity	Neutral Soda	Colloidal	Soda Ash	Trisodium phosphate	Special Alkalies
Total Alkali	Trisodium phosphate	Colloidal	Soda Ash	Neutral Soda	Special Alkalies
Stability of Alkalinity	Trisodium phosphate	Special Alkalies	Soda Ash	Neutral Soda	Colloidal
Drop Number	....	....	....	....	....
Benzene	Neutral Soda	Soda Ash	Special Alkalies	Colloidal	Trisodium phosphate
Butterfat	Trisodium phosphate	Neutral Soda	Colloidal	Soda Ash	Special Alkalies
Water Softeners	Trisodium phosphate	Special Alkalies	Neutral Soda	Colloidal	Soda Ash
Corrosion	Neutral Soda	Colloidal	Soda Ash	Trisodium phosphate	Special Alkalies

Barnum, Lucas, and Hartsuch warn against injudicious use of washing powders containing abrasives, for tinned copper and tinned steel were scratched, nickel was slightly affected, and ascoloy and chrome-nickel steel were unaffected.

Special alkalies were very severe on metals commonly used in dairy equipment. Tinned steel was most affected and, in order, came aluminum, tinned copper, and copper. Nickel was slightly affected and ascoloy and chrome-nickel steel were entirely resistant.

Germicidal Properties of Washing Powders. Phillips, Mack, and Frandsen [2] in 1928 reported that washing powders studied by them showed disinfecting powers in 0.6 per cent solutions by rendering wash-water sterile. They did not present data on this point.

Meyers [3] in 1928 studied the effect of hydroxyl-ion concentration on germicidal efficiency. He showed that hydroxyl-ion concentration, buffer ingredients, temperature of solution, and time of exposure play a part in germicidal efficiency.

Levine and Buchanan [4] in 1928 reported that death rates were not constant but increased progressively with duration of exposure.

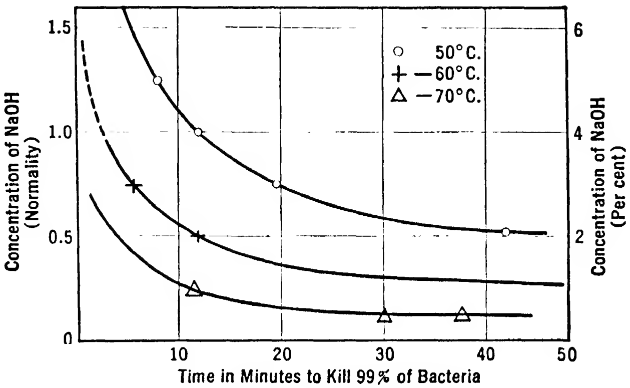

FIG. 100. Germicidal properties of alkaline solutions. Three factors are important, viz.: (*a*) strength of alkaline solution, (*b*) time of exposure of organisms, (*c*) temperature of the solution. After Levine & Buchanan.[4]

They used a death-time standard, or the time required to kill 99.9 per cent of the bacteria.

Data from their work are presented in graphical form (Fig. 100). It will be noted that for brief exposures 3 per cent of NaOH concentration and temperatures of 70° C. (158° F.) are required. This coincides with data recommended for soaker-type bottle washers.

Loss of Strength of Alkali and Chlorine Solutions. It should be remembered that the efficiency of washing powders, both from the standpoint of cleaning and disinfection, depends also on the amount of foreign material encountered. The strength of solution is depleted as the amount of foreign material accumulates. Chlorine solutions used as disinfectants and deodorants may be rendered quite useless unless they are used on surfaces already free from milk, cream, and foreign material, with which chlorine combines.

QUESTIONS

1. Name some chemicals used as washing powders.
2. List and give some properties of several types of commercially blended powders.
3. What types of powders should be used for churns? Vats? Glassware? State reasons.
4. State some precautions for the use of washing powders on churns and vats.
5. Upon what does the efficiency of chlorine disinfectants depend?

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CHAPTER 18

SANITATION

All operations in the creamery hinge on the single consideration of cleanliness. Buildings are designed and equipment and utensils are made and improved largely from the standpoints of neat appearance, accessibility, and ease of maintenance and cleaning. Walls and floors are made of smooth impervious material. Window space is liberally provided. Boiler rooms and coal bins are shut off to eliminate dust and odors from the creamery work room.

The factors listed above furnish the proper background for the more technical considerations of sanitation and the handling of cream and butter. It becomes increasingly necessary that a plant operator should know about the physical, chemical, and bacteriological aspects of his work. Without this information he may make serious mistakes, even though he is painstaking in his work.

General Sanitary Considerations. Two lists are given below covering sanitation from the aspects of (*a*) creamery and equipment and (*b*) personal hygiene.

Cleanliness in the creamery:

1. Pumps and pipe lines.
2. Pails, cans, and cream strainers.
3. Stuffing boxes on churns and vats.
4. Wash sinks.
5. Weigh cans and faucets.
6. Buttermilk tanks.
7. Patrons' cans not to be used for buttermilk.
8. Fresh water tanks for washing butter.
9. Elimination of pulleys, belts, and shafting wherever possible.
10. Protection of open vats from droppings from overhanging pipes, shafts and unkept ceilings.
11. Windows and doors properly screened against flies.

12. Churn screened against flies, etc.
13. Painting.
14. General orderliness.

Personal hygiene:

1. Proper care and laundering of clothes.
2. Use of caps and white gloves.
3. Care and use of towels.
4. Shaving.
5. Care of dressing rooms and toilets.

Merely drawing attention to these considerations is in many cases sufficient to direct the operator's efforts in essential sanitary requirements. It is imperative that cream pumps and pipe lines be taken apart and thoroughly cleaned and dried. Pails, cans, and cream strainers must be scoured with washing powders or detergent. It is not enough to rinse and steam them, a practice which allows accumulation of milk constituents and sediment. Bacteria collect in these deposits, and cans thus neglected are unfit.

Stuffing boxes on vats and churns are frequently neglected as long as no leaks are noticeable. They should be repacked frequently and drawn gradually tighter to insure sanitary conditions. Further discussion appears under "Care of Equipment," Chapter 15.

Wash sinks and buttermilk tanks must be cleaned regularly. Carelessness may lead to spreading foul fermentations to cans and other creamery equipment.

Patrons should not be permitted to take buttermilk in cream cans. Cream quality is almost certain to be lowered if this is allowed. It is far better to sell buttermilk on annual bids to an individual if possible.

Considerations 9 to 14 need no explanation. Attention to these points is only part of the general scheme of orderliness and cleanliness. If creameries are to be rated or classified, these things are always given due prominence.

External appearance of creameries is being given much attention. Creamery sites are now frequently selected in, or adjacent to, the business section in cities. Attractive brick or tile buildings are common. Grounds are landscaped and well cared for. An attractive appearance lends confidence and respect to all phases of the enterprise.

The matter of personal hygiene must be considered carefully. All employees must be in good health. Clean, well kept clothes should be worn, and personal appearance should always be creditable. The handling of cream and butter should be done in a manner which would invite inspection by the public at any time.

Toilets and dressing rooms should be clean and orderly. An appeal to the pride of workmen is probably the best approach to this problem. Washing of hands after the use of toilet rooms should not only be habitual but also compulsory.

Sanitation Must Accompany Pasteurization. A capable creamery operator should have at least an elementary understanding of bacteriology in order that he may clearly visualize just what will happen to milk, cream, starter, etc., if these products are not consistently protected at all times. It is not enough that he should pasteurize cream and feel that he has done everything in his power to make the best grade of butter possible from the kind of cream delivered. Pasteurization is but one step in the continuous chain of operations in the creamery.

Laboratory Service of the American Association of Creamery Butter Manufacturers. The control laboratory of the American Association of Creamery Butter Manufacturers (renamed, 1937, American Butter Institute) has long given a most valuable service to its members. Great credit is due the late Dr. G. L. McKay for the establishment and development of the service to a high point of efficiency. Complete butter analyses and bacteriological and chemical tests of a wide variety are made. In making yeast and mold counts on butter and on cream, a very valuable service has been given the members of the Association. It is found that the best butter invariably is produced in the creameries which have the lowest yeast and mold counts on cream and butter. Thorough pasteurization by any standard method will destroy practically all yeasts and molds. When mold and yeast counts run high in butter, the cream is contaminated, usually after it leaves the pasteurizer. It is of paramount importance that every buttermaker understand the need of constant effort to see that as little contaminating matter as possible comes in contact with the cream and the butter.

Land O'Lakes Standard Requirements. One of the most complete check-up systems to aid in preventing recontamination after pasteurizing is used by the Land O'Lakes Creameries, Inc., of Minneapolis, Minnesota. Complete sets of sterile sample bottles are provided each member creamery, and detailed directions for taking samples are given. These samples are mailed promptly to the company's laboratory, and yeast and mold counts are made. The results are a wonderful help to the creamery operator in locating the sources of contamination. The samples taken are:

1. Starter used, if any.
2. Raw cream.
3 Pasteurized cream.
4. Wash water through pipes and pumps (sterile water rinse).
5. Buttermilk.
6. Wash water in the churn (sterile water rinse).
7. Butter without salt.
8. Butter with salt.
9. Wash water from packing tools (sterile water rinse).
10. Water supply.
11. Wash-water tank.
12. Parchment-paper solution.
13. Sterile water rinsings from paraffined tubs ready for use.

Counts on these samples will usually reveal the source or sources of greatest contamination so that the operator is in a position to remedy faulty conditions. If tubular coolers or additional pumps and piping are used, obviously samples must be taken from sterile water rinsings and from cream passing over or through such equipment. It has been found from thousands of laboratory reports that eternal vigilance is required and that frequent check tests must be made.

YEAST AND MOLD COUNTS ON BUTTER—LAND O'LAKES CREAMERIES, INC.

(Rating card used by Land O'Lakes, Inc.)

Number of Yeast and Mold per Cubic Centimeter of Butter	Grade
none	excellent
1 to 10	good
11 to 50	fair
above 50	poor

Sanitation in Creameries. Macy and Combs[1] in a survey in 1925 found widely variable conditions in creameries. Creameries "P" and "B" represent good and very bad conditions, respectively. They report findings in Creamery "B" as follows:

CREAMERY B (MOLD COUNTS)

Sample	Observations made on	
	7/20/25	8/19/25
Raw cream (vat I)	+++	+++
Pasteurized cream (vat I)	++	—
Raw cream (vat II)	+++	+++
Pasteurized cream (vat II)	—	—
Starter	—	—
Rinsings from hose, pump and pipe	+++	+
Rinsings from churn	+++	+++
Butter (unsalted) vat I	+++	++
Butter (salted) vat I	+++	++
Butter (unsalted) vat II	+++	++
Butter (salted) vat II	+++	++
Liner from formalin solution	—	—
Buttermilk from tank	+++	+++

— means no mold. + means less than 10 mold colonies per cubic centimeter.
++ means 10 to 100 mold colonies per cubic centimeter. +++ means too many colonies to count.

On July 20, Vat 1 was pasteurized by the buttermaker. Vat 2 was pasteurized by the authors, who found the cream to be of the same quality as that in Vat 1.

It will be noted that the count on the pasteurized cream was between 10 and 100 mold per cubic centimeter when pasteurized by the creameryman. Part of the same cream pasteurized in Vat 2 by the authors showed no mold.

The building was of frame construction, poorly ventilated, and with mediocre equipment. Common iron piping, permanently installed, conveyed cream to the churn. A rubber hose conveyed cream from the vat to the cream pump. Samples from this equipment showed very heavy contamination. An inspection on August 19 showed improved conditions, although still very unsatisfactory. Whereas the pump and pipelines showed better condition and care, the churn remained the greatest source of contamination. It was old, and even with drastic treatment, was not satisfactorily cleaned.

Attention is directed to the use of such equipment as a *rubber hose* and *common iron piping permanently installed.* This equipment is inexcusable. State inspectors should condemn creameries using such equipment. Creamery operators should see that everything in the creamery is scrupulously sanitary.

CREAMERY P (MOLD COUNTS)

Sample	Observations made on	
	9/14/26	9/15/25
	Lot I	Lot II
Raw cream in prewarmer	+++	+++
Cream, at 120 degrees F., from generator	+++	+++
Cream, at 152 degrees F, through first heater	−	+
Cream, at 180 degrees F., through second heater	−	−
Cream, coming out of regenerator	−	−
Cream, coming out of cooler	−	−
Cream in vat I	−	Vat II −
Rinsings from pipes and pump	−	−
Rinsings from churn A	−	Churn B +
Cream in churn A (vat I)	−	Ch. B (vat II) +
Butter (salted) from churn A (vat I)	−	Ch. B (vat II) +
Buttermilk from churn A (vat I)	−	Ch. B (vat II) ++
Starter	−	−
Water from well	−	−
Brine solution	−	−
Parchment from brine	+	+

1. Heating to 120° F. had no destructive effects on mold.
2. Heating to 152° F. destroyed mold one day but not the next.
3. Heating to 180° F. in two steps destroyed all mold in both instances.
4. Churn B recontaminated the cream, whereas Churn A caused no trouble.
5. Churn A is an excellent example of possibilities in cleaning churns.
6. Churn B had been scalded two days before but was not used the day intervening. This gave mold a chance to develop.

Care of Parchment. Reports from several creameries surveyed by Macy and Combs [1] showed cloth circles and unboiled parchment paper as heavily seeded with mold. This is entirely the fault of the operator in carelessly placing these supplies on open shelves where they are readily contaminated with dust which carries yeast, mold, and bacteria.

Macy and Pulkrabek [2] reported that parchment paper is so handled in its manufacture that freshly opened cartons are very seldom found to be contaminated. Parchment paper was found to be most contaminated at creameries where it was removed from the containers and placed on exposed shelves, where it soon became contaminated with dust and dirt. The following tables from Minnesota Bulletin 242 [2] show the effect of treated and untreated parchment paper on the development of mold on butter and on the paper.

MOLD DEVELOPMENT ON STERILE BUTTER WRAPPED IN CONTAMINATED PARCHMENT

(Minnesota Bull. 242)

Storage, degrees F.	Time in humid air, days	Time in dry air, days	No. of samples	Per cent of samples showing mold	
				Butter	Parchment
35	—	50	12	0	0
35	10	50	5	60	0
35	10	50	5	100	60
55	20	60	8	100	87.5
—	20 at 55° F.	60 at 35° F.	7	100	100
—	20 at 55° F.	60 at 35° F.	7	14.3	0
55	—	30	10	0	0

It will be noted that in all but one instance the chemicals did not prevent contamination of the parchment. Humidity and higher temperatures favored this contamination. Of all the disinfectants used on parchment paper, none was effective in preventing the mold-contaminated butter from contaminating the parchment, except the benzoic acid. This is quite conclusive proof that poor butter cannot be stored long in treated parchment without danger of trouble from mold.

Macy and Pulkrabek [2] do not recommend the use of chemicals in treating parchment. Standard practice consists in scalding the liners, circles, and wrappers in a strong brine solution for one-fourth to one-half hour.

BUTTER CONTAMINATED WITH MOLD—WRAPPED IN STERILE PARCHMENT

(Minnesota Bull. 242)

Treatment	Strength solution, %	Time treated, hours	Appearance after 6 weeks			
			Low humidity		High humidity	
			35° F.	55° F.	35° F.	55° F.
Check—untreated	....	....	*B*	*B*	*BP*	*BP*
Boiling water	....	1/12	*B*	*B*	*BP*	*BP*
Boiling brine	35.0	1/12	*B*	*B*	*BP*	*BP*
Cold brine	35.0	20.0	*B*	*B*	*BP*	*BP*
Benzoic acid	0.5	1/2	*B*	*B*	*B*	*BP*
Boric acid	5.0	1/2	*B*	*B*	*BP*	*BP*
Formalin	1.0	20.0	*B*	*B*	*BP*	*BP*
Salicylic acid	0.1	1/2	*B*	*B*	*BP*	*BP*
Sodium benzoate	1 0	20.0	*B*	*B*	*BP*	*BP*
Calcium hypochlorite	0.5	1/2	*B*	*B*	*BP*	*BP*
Sodium hypochlorite	2.0	1/2	*B*	*B*	*BP*	*BP*
Commercial chloramine	0.2	1/2	*B*	*B*	*BP*	*BP*

B—Mold on butter. *BP*—Mold on parchment and butter.

Care of Churn. The churn is the most frequent cause of high yeast and mold counts in butter. All other dairy equipment is made of metal, except ladles, malls, butter-print boxes, and tubs. This minor equipment is all small and is easily washed, scrubbed, and scalded.

A very different problem is encountered in washing churns. Most churns are more or less inaccessible and cannot be scrubbed after each day's operation; in fact they cannot be scrubbed at all without dismantling. Many churns have been in use for a number of years without ever having been taken apart and thoroughly scrubbed and cleaned. In fact most churns are washed during their entire life without the shelves and rollers being removed for a thorough renovation. It is indeed remarkable that careful operators can keep a churn in as good condition as many do. The more a churn is used, the easier it is to keep it clean. It becomes a most difficult task to keep a churn in suitable condition when it is used but two or three times a week. The idle hours give mold, yeast, and bacteria a chance to multiply in great numbers, and particularly so if the churn is not well drained and aerated. Even with care in this respect, moisture remains in the soft wood of the churn for hours and microorganisms increase in vast numbers. They are lodged deep in the pores of the wood as well as on the surface and remain as a constant menace and source of contamination. Their complete removal is impossible. To destroy them is almost impossible. Water heated to 180° F., or more, is the most effective means. This method is used by many, and has come into greater use during the past few years, since laboratories have disclosed the fact that churns are so often at fault.

Olson and Hammer [3] studied the contamination of churns. Their review of literature and results is most pertinent, and the references listed below are taken from their work.

Carefully selected and cured wood is the most practical material for making churns. However, it is relatively porous and affords access to particles of cream which, if not removed, furnish food for microorganisms. The development of combined churns and workers brought forth further difficulties in churn care and sanitation. There are not only many inaccessible parts but there are also rollers which move and have bearings where cream lodges. Churns are a constant menace to butter quality unless the utmost care is used to keep them washed, cleaned, and disinfected. Some buttermakers are grossly negligent with churns. Because laboratory service has revealed this fact to many operators much improvement has been made in the last few years.

Lund in Canada, in 1920, found churns to be the greatest single source of recontamination of properly pasteurized cream. Treatment with chloride of lime or with hot water was not effective in removing the contamination. Treatment with hot alkali solution, followed by fresh hot milk of lime together with occasional repacking of stuffing boxes, was quite satisfactory. He stated that, where high yeast and mold counts are found regularly, nine times out of ten the churn is responsible.

Gregory in 1920 found that many organisms remained in the churn after six different treatments but that some treatments were much more effective than others. Commercial germicides gave very encouraging results.

Bouska and Brown in 1921 found more organisms in worked butter. They attributed this to movement of the rollers, which loosened lodged material.

Stritz in 1922 recommended yeast and mold counts as a check on the entire buttermaking process rather than a mere check for efficiency of pasteurization because of recontamination due to churns in particular.

Haglund, Barthel, and Waller in 1926, in Sweden, showed that boiling water was the most effective of four methods used in cleaning churns as far as yeast and mold were concerned. This is in accord with the findings of Morrison, Macy, and Combs in 1931.

Hood and White in Canada in 1925 stated that the churn is the most troublesome source of contamination and recommended regular liming of the churn.

Quam in 1927 showed that considerable numbers of organisms remained after hot water and hot milk of lime were used. A significant reduction occurred when Diversol, one-half ounce per gallon of water and with a 5-minute exposure, was used after the lime treatment. One ounce of Diversol in 50 gallons of water at 120° to 125° F. for 5 minutes was still better. The best results were obtained by treating the churn with hot water and hot milk of lime, following with a chlorinated lime wash (6 ounces to 10 gallons of cold water). In all cases, before and after treatment of the churns, the numbers of bacteria were much greater than the numbers of yeast and mold.

Morrison, Macy, and Combs in 1931 reported that chlorine solutions ranging from 35 to 265 p.p.m. (parts per million), with periods of exposure varying from one-half hour to 18 hours, were ineffective in reducing either mold or bacterial counts. They used solutions at 50° to 60° F. Chloramine T solutions in concentrations of 46 to 350 p.p.m., and at temperatures of 118° to 125° F. with exposures of 2 to 18 hours, were used and effected only slight reductions of molds and no significant reduction in bacteria. They concluded that sufficient exposures to hot water and flowing steam were the most satisfactory methods of cleaning churns.

Coulter in 1930 found that a hot salt paste, rotated in the churn a few revolutions and then drained, produced quite satisfactory results. A question might arise here as to the effects of such treatment on exposed metals in the churn.

The above review of studies in churn contamination is from the work of Olson and Hammer previously cited. The results of the work reported by these authors are given below.

The use of sodium hypochlorite, chlorinated lime, and calcium hypochlorite on churns treated with hot water effected large reductions in bacterial counts and appreciable reductions in yeast and mold counts. Cold saturated brine applied after hot water did not reduce counts. The use of chloramine sterilizers was not so satisfactory.

Serious contamination of butter may occur in carefully washed and treated churns. An instance is cited where a loose shelf brace caused serious contamination. This trouble was eliminated when the brace was replaced.

The keeping quality of salted butter from the contaminated and uncontaminated churns showed no great difference at 32° and 45° F. storage temperatures. The keeping quality of unsalted butter from the clean churns was distinctly better. The unsalted butter from the unclean churns showed a definite decrease in quality at both 32° and 45° F. storage temperatures. Rancidity developed in the butter from the unclean churns.

Personal comment on the foregoing review of literature and experimental work must include such statements as:

1. The churn is a very difficult machine to keep in sanitary condition.
2. A complete realization of this fact is the first essential to any success attainable in churn sanitation.
3. There seems to be more agreement in satisfactory results obtained with the use of very hot water (180° F. or above.)
4. The operator must completely wash and treat a churn after each day's run or there are likely to be undesirable consequences.
5. The churn must be kept in good mechanical condition at all times. Loose shelves, braces, or worker bearings must not be neglected. Gear ends must be repacked frequently.

6. Stainless-steel metal parts and bolts as now used in churn construction are highly desirable, and particularly so if such chemicals as chlorine, salt, and lime are used to disinfect the churn.
7. Occasional use of lime and chlorine solutions facilitates churn sanitation.

Preparation of Butter Tubs and Boxes. It is important to have the churn clean and to have the butter as free of yeast and mold as possible. Parchment liners and circles must be kept covered and clean until used. They must be treated as previously described to guard further against mold. Logically, then, butter tubs must be so prepared that they are not a source of trouble. The most practical method is steaming them thoroughly over a steam jet and then spraying the interior with hot paraffin. The steamed tub should be quite free of mold. The hot paraffin seals the wood pores, leaving a smooth clean surface. It is imperative to:

a. Steam the tubs long enough.
b. Have the paraffin at 225° F. or higher.
c. Allow the excess paraffin to drain from the tub before removing from the paraffiner.

Paraffin may be a source of mold if it is not heated enough before being used and especially so when reconditioned tubs are used. Removing the tubs from the paraffiner too soon may produce a thick coating of paraffin which may scale and fall from the tub, leaving unparaffined spots. Tub covers may or may not be paraffined. It is believed advisable to paraffin used tub covers. Many creamery operators invert the filled tubs when placing them in the refrigerator. Poorly prepared covers may cause trouble in such cases. The tubs are inverted, and the fresh butter settles to produce a smoother finish.

Tubs must be kept clean and free from greasy finger marks. Parchment liners must be folded evenly. Tubs must be full, but the butter should not extend above the edge of the tub as it may be pressed between cover and tub and make an unsightly package. It must be kept in mind that much butter is sold to consumers as it comes from the creamery. A poor or soiled package often causes sales disadvantages.

Corrugated paper boxes are used by some creameries. These should be paraffined either with jets or with brushes. Hot paraffin is always an aid in mold control. Both tubs and boxes, if unparaffined, may be the source of weight troubles. An unparaffined tub containing 64 pounds of butter may underweigh when it reaches the market. Buyers pay for whole pounds and disregard fractions. A tub weighed out at 64 pounds and 6 ounces may weigh less than 64 pounds, and payment would be made on 63 pounds. Rogers found shrinkage on 12 tubs as follows:

	Paraffined	Not Paraffined
From churn	$757\frac{3}{4}$ pounds	$766\frac{3}{4}$ pounds
After 8 days	756	759
Loss	$1\frac{3}{4}$ pounds	$7\frac{3}{4}$ pounds

An unparaffined container will absorb water from the butter, and the water then evaporates from the surface of the package. Paraffin prevents absorption.

Formalin solutions and strong brine were formerly used but were less satisfactory. Many buttermakers formerly soaked tubs in cold water and dashed them with salt before lining. When the tubs were full they sprinkled salt on the top circle. This tended to induce greater shrinkage and was not entirely satisfactory in preventing mold.

Occasionally buttermakers are careless about mauls, paddles, strikers, etc. This equipment should be kept smooth and should be washed in strong alkali solutions before use. These solutions disinfect, clean, and prevent butter sticking to the equipment. As an intake man is judged partly by the cleanliness and orderliness of his testing glassware, so is a buttermaker judged partly by the cleanliness of packages and packing tools.

Butter should be firmly packed to avoid air pockets. Stripped tubs of butter which show air pockets are unsightly to the purchaser. Furthermore, they provide space and air for mold growth.

Spruce is now quite universally used for butter tubs. Until 1925 ash was used quite exclusively. Ash is heavier than spruce and caused some difficulty in nailing tub tins. Ash tubs dried out in storage and required soaking before use. Some tubs were lost because they fell apart. Spruce was slow in being accepted because of a prevailing idea that it imparted woody flavor to butter. The general practice of paraffining tubs avoids any such possibility.

Poplar and spruce are most commonly used for butter boxes. Turnbow[4] used white fir, cottonwood, and spruce for butter boxes. White fir and spruce were satisfactory and cottonwood was found to impart some woody flavor. Davis and Morbeck[5] tested white ash, white fir, soft maple, hackberry, sycamore, aspen, beach, yellow poplar, elm, black gum, basswood, cottonwood, red gum, and magnolia, finding their flavor and odor imparting properties from least to greatest in the order given. Fourteen-day test periods were made. The moisture content of woods influenced their flavor imparting properties. Woods with 20 per cent or more of moisture cannot be recommended.

Making Chlorine Solution: From Bull. 154 Agricultural Series, Federal Board of Vocational Education, "Analyses of Special Jobs in Quality Milk Production," 1931.)

Calcium hypochlorite solutions:

Use 12 oz. commercial calcium hypochlorite (30% available chlorine).
Make a paste; then add water to 2 gal. volume.
Allow to settle.
Drain or siphon clear chlorine solution and store in a stoppered jug.
Use 1 pint in 8 gal. of water.
Use at once. Do not hold diluted solutions over.

Sodium hypochlorite solutions:

Use 12 oz. commercial calcium hypochlorite (30% available chlorine).
Make a paste.
Follow with water to a volume of 1 gal.
Dissolve 27 oz. crystalline washing soda in 1 gal. of water.
Mix the 2 solutions.
Allow to settle, and then siphon clear liquid to suitable storage jug.
Use 1 pint of this in 8 gal. of water.
Do not hold diluted solutions over.

Both the above stock solutions contain about 200 p.p.m. (parts per million) of available chlorine when diluted as directed for use.

QUESTIONS

1. Discuss the effects of attractive creamery buildings, grounds, and equipment on:
   a. The cream producers.
   b. Employees of the creamery.
   c. Consumers of butter.
2. How will technical training aid the creamery operator in his work?
3. Make a list of the samples to be collected for laboratory analysis when checking all operations in the creamery.
4. Discuss measures for keeping a churn clean and sanitary.
5. Why is an infrequently used churn difficult to clean?
6. Describe a satisfactory method of preparing butter tubs for use. State the objects of such treatment.

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CHAPTER 19

TESTING

Sampling. Before any testing of dairy products is attempted, a sample must be obtained which must be representative of the product to be tested. This sample must be properly sealed and refrigerated, or preserved if it is not to be tested at once. *Too much emphasis cannot be given proper sampling.* Fine technique in making tests is necessary and is creditable, but if the sample is not thoroughly representative of the material being tested, the results are worse than none at all. They are misleading. Improper samples of butter may lead to the making of illegal butter and serious difficulty. Improper samples of milk and cream may have similar consequences. When payment for milk and cream is based on tests, carelessness or ignorance are inexcusable. *The samples must be representative.*

One large creamery in the middle west found irregularities in overrun. Composition tests of the butter showed that the churning and working were properly done. A check was made on the sampling and testing of cream in the intake. It was discovered that the testing was done properly. It happened that incorrect samples were being taken. The same men weighed and sampled so many cans of cream during the day that they grew tired and did not stir the cream enough before taking samples. Small, motor-operated, cream-stirring devices were put into use and the trouble disappeared.

Sampling Milk. Carelessness in taking milk samples may be more frequently observed than carelessness in taking cream samples. Possibly this may be accounted for because of the greater fluidity of milk and the idea that less stirring suffices. This is quite erroneous, because fat separates in milk far more readily, and complete stirring is essential for correct sampling.

The use of a weigh can is preferable to individual-can sampling. Accurate samples from several cans may be obtained if the cans are all of the same height, diameter, and fullness and if care is taken to have all cans of milk fully stirred. It is common practice to have some partially filled cans and some cans of different sizes.

The use of the weigh can, however, does not insure accurate sampling. Marquardt and Durham[1] reported satisfactory results

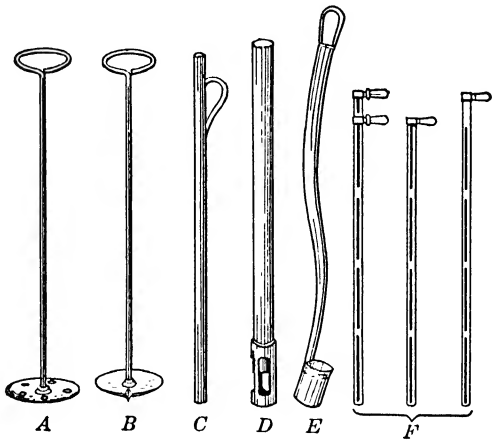

Fig. 101. Milk and cream samplers.

A and *B*—Common stirring rods.

C—Milk-thief Sampler. Sample of whole milk is taken by inserting into milk to bottom of weigh can, placing thumb over top of tube, and withdrawing. Release thumb and permit sample to flow into sample bottle.

D—Scoville Sampler. Inserted into milk in manner similar to *C*. Lower end automatically closes when sampler strikes bottom of can.

E—Common Dipper Sampler.

F—McKay Sampler. Two telescoping metal tubes are turned one-half turn after plunging to bottom of can; sampler withdrawn and contents placed in sample bottle.

in sampling immediately after dumping in the weigh can. More recent work by Bailey[2] indicates that differences as great as 2 per cent were obtained with samples taken at the two ends of the weigh can or tank. When the milk was thoroughly stirred, either before or after dumping, accurate samples were obtained. It was found also that the use of fine-mesh strainers in weigh cans interfered with correct sampling. The extent of creaming of the milk before dumping was a factor. On well-creamed milk, the fat did not pass through the strainer. The use of weigh-can strainers is prohibited in some states. Motor-driven agitators on weigh cans are now used quite extensively.

Bailey's work indicates that extreme care is required. Successful plant operation and justice and satisfaction to producers are essential. Accurate sampling and careful testing cannot be neglected.

Testing Cream. Two- or four-ounce samples of cream are taken for testing. Many creameries now take the larger sample, which furnishes enough for the fat test, acidity test, and the sediment test. These jars are usually of the screw-top or rubber-stopper type. The jars and covers must be clean, free of sediment, and they must be kept inverted until used. They should be rinsed well to remove any alkali used in washing them because of interference with correct acidity tests. The directions for testing cream are:

Weigh 9 grams of cream in a 9-gram, 50 per cent cream-test bottle. (See state laws, p. 392. Some states require 18-gram bottles.)

Add 10 to 14 cc. of sulphuric acid of 1.82 to 1.83 specific gravity.
Mix without delay until a very dark chocolate color appears.
Add 10 to 15 cc. of hot water (130° to 140° F.).
Centrifuge while hot.
Run tester 5 minutes.
Add hot water to bring fat well into neck of bottle.
Run tester 2 minutes.
Remove test bottles, placing them in hot-water bath, 130° to 140° F., and allowing them to stand 5 minutes before reading the percentage of fat.
Level of water in bath should be sufficient to heat the fat in the neck of the bottles.
Carefully add a few drops of glymol or "red reader" to each bottle, and read the tests at once.
Cream must be weighed for testing because:

1. Specific gravity of cream varies inversely with the percentage of fat.
2. Cream retains more air than milk and, if sour or fermented, may contain considerable foam.

3. Cream, being viscous, cannot be measured with a pipette because too much cream sticks to the glass.

If testing difficulties are experienced or fat columns are not clear, refer to any standard testing textbook for explanation.

Testing Milk:

Have the temperature of the milk at 60° to 70° F.

Pour three or four times from one receptacle to another.

Pipette 17.6 cc. at once to test bottle.

Add 17.5 cc. of standard sulphuric acid (sp. gr., 1.82-.83).

Mix thoroughly without delay and continue agitating for one-half minute.

Do not add hot water.

Centrifuge 5 minutes.

Add hot water to arch of neck.

Centrifuge 2 minutes.

Add hot water to bring fat well into neck.

Centrifuge 1 minute.

Set in water bath, 130° to 140° F. for 5 minutes.

Remove and read at once.

Do not use glymol.

Read from upper to lower limits of fat column, including both menesci.

This is necessary because results check with official chemical analyses of milk.

Testing Buttermilk. *Babcock Method.*

Use 8.8 cc. of well-stirred sample, placing in a skim-milk test bottle of 50/100 per cent capacity.

Add 7 to 9 cc. of sulphuric acid in about three portions, mixing each portion with the buttermilk.

Centrifuge three times, 8-2-1 minutes, adding hot water as directed in milk tests.

Set in hot water bath for 5 minutes and read.

Double the reading.

Modified or Babcock Butyl Alcohol Method. (Also known as the American Association test.) Procedure is the same as the regular Babcock test except 2 cc. of normal butyl alcohol is mixed with the buttermilk before addition of sulphuric acid.

Much clearer fat columns are secured by this method, but the tests read about double the percentage obtained with the straight Babcock buttermilk test.

Minnesota Reagent Test: [3]
Use 9 grams of buttermilk in skim-milk test bottle.
Add 10 cc. of the Minnesota solution; shake thoroughly.
Place in hot water bath at 160° to 180° F. for 6 to 7 minutes.
Shake several times while in the bath.
Centrifuge 5 minutes and add hot water to base of bottle neck.
Centrifuge 2 minutes and add hot water to raise fat in neck.
Centrifuge 1 minute.
Place in hot water bath for 5 minutes; 130° to 140° F.
Double reading for correct fat test.

The official acceptance of the method is not known. It can be used for other dairy products, varying the amount of reagent used and the time of heating in the water bath. Results of this test when used on buttermilk show readings which are somewhat higher than

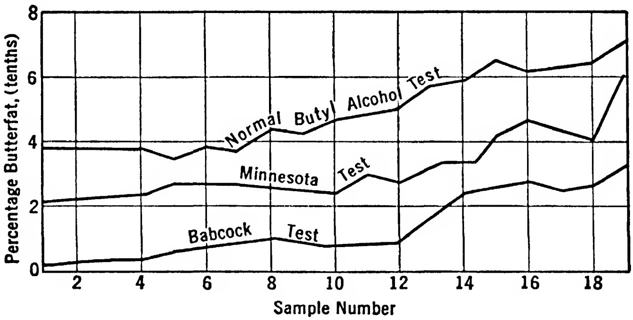

Fig. 102. Comparison of 20 samples of buttermilk from many Minnesota creameries, using three different tests. Several hundred samples were tested in 1929-1930. W. B. Combs.[4]

Note: The reader is to guard against the impression that buttermilk fat tests are frequently less than 0.20 per cent. Yearly averages show 0.40 to 0.50 per cent fat losses.

the straight Babcock method. Combs[4] shows that the readings from tests with the Minnesota reagent are midway between those in which the butyl-alcohol and the straight Babcock methods are used. The higher fat content of buttermilk resulting from the butyl-alcohol and Minnesota tests is more comparable to official chemical analysis such as the Rose-Gotlieb method. The higher readings are due to the fact that lecithin, a fatlike substance, is recovered with the true butterfat.

Factors affecting the variations in buttermilk tests made with the Minnesota reagent are:

1. Amount of reagent used.
2. Period of digestion and temperature used.
3. Time and speed of centrifuging.

Minnesota Bulletin 63, 1929, recommends a centrifuging time of 5, 2, and 1 minutes and a digestion period of 6 to 7 minutes at 158° to 178° F. Later directions from the Minnesota Station recommended two, 30-second centrifuging periods. (Mimeographed directions, 1931, E. O. Herried.) The Kimball-Nafis Company in 1935 sold a Minnesota reagent which was tested at the Iowa Station.[5] Results gave lower tests with the 1935 reagent than with the two original Minnesota reagents recommended by the Minnesota Station. Two 30-second centrifuging periods were recommended by the Kimball-Nafis Company. However, there was some difference in results by the two reagents recommended by the Minnesota Station. These differences were small when the digestion period was limited to the time recommended, 6 to 7 minutes.

Since buttermilk is not bought or sold on the fat basis, the importance and reliability of any of these tests are secondary. The important thing is to test the buttermilk regularly and to so arrange churning conditions as to keep fat losses at a minimum. However, a reliable and accurate test is desirable in checking plant losses of butterfat.

Kohman Analysis of Butter: *Testing for Moisture.*

Place the 1-gram (upper) slide weight of the scale to the right at the 10 per cent mark and the 2-gram lower slide weight at the left at the zero mark.

Balance a clean dry cup on right pan of moisture test scale (metal cup 2½ × 2½ inches).

Weigh 10 grams of butter into the cup.

Evaporate moisture until a brownish color appears in the cup contents.

The open flame or electric hot plate may be used.
Heat slowly to avoid sputtering of fat.
Cool cup and balance with large slide weight.
Record percentage of moisture.
Fill cup about one-third full of high-test gasoline and stir into fat. Let settle 5 minutes and decant fat-gas solution.
Repeat with 2 successive washings with gasoline, using not over

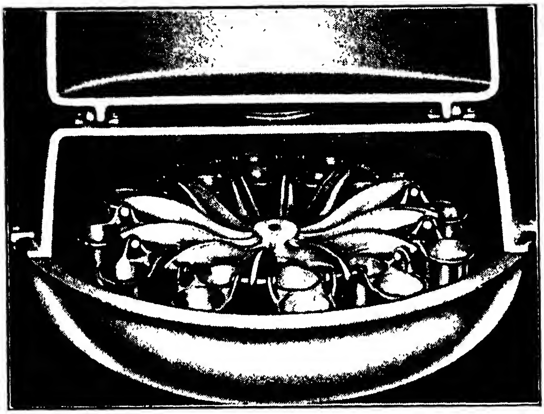

FIG. 103. Modern electric tester.

one-fourth cupful. Allow to settle 5 minutes before decantation.
Dry cup over hot plate or steam plate until contents show light tan color and do not have odor of gasoline.
Do not use open flame to dry.
Cool cup and weigh. Remove the 10-gram weight from left pan and see that the 2-gram bar slide weight is at zero.
Now move the upper slide weight to the left until scale balances.
Record the weight as percentage of curd and salt.

Example. If the weight produces a balance by moving from the 10 per cent mark to the 7 per cent mark, then the percentage of curd and salt is recorded as 3.0.

The 10 per cent mark is zero, the 9 per cent mark corresponds to 1 per cent, etc.

Testing for Salt. Now place 100 cc. of distilled water in the metal cup and stir with clean glass rod.

Heat to 110° to 130° F. and pour 10 times, or more using another clean receptacle.

Draw 10 cc. with a pipette and titrate in a white cup or other suitable clean container, using 3 or 4 drops of potassium-chromate indicator.

Draw silver-nitrate solution from a burette until a red-brick color appears. Stir constantly so that the first permanent appearance of the color is noted.

No more silver-nitrate solution is required.

Read the number of cubic centimeters from the burette and record as the percentage of salt in the butter.

Subtract percentage of salt from percentage of salt and curd, and record as percentage curd.

Add moisture, salt, and curd, and subtract from 100 to get percentage of fat in the sample.

Example of recorded results:

Moisture......	16.0%
Salt and curd..	3.0%
Salt..........	2.4%
Curd.........	0.6%
Moisture, salt, and curd.	19.0%
Fat (100–19.0)........	81.0%
Total..............	100.0%

The potassium-chromate indicator is made with 10 grams of the chromate crystals in 100 cc. of distilled water. The silver-nitrate solution should contain 29.06 grams per liter. Do not attempt to make these solutions. Buy them from reliable dealers. Silver nitrate should be kept stoppered in brown-glass bottles, should be drained from the burette, and should not remain exposed from day to day, as light weakens the solution. As photographic plates, which contain silver salts, are promptly affected by light, so does light slowly change the silver-nitrate solution unless it is stored in dark brown bottles.

Principle of the salt test:

Molecular weight of $AgNO_3 = 108 + 14 + (3 \times 16) = 170$

" " " $NaCl = 23 + 35.5 = 58.5$

Chemical reaction: $AgNO_3 + NaCl = AgCl + NaNO_3$

Hence they combine in 170 to 58.5 weights.

$$\text{Ratio of reaction} = \frac{170}{58.5} \text{ or } 2.906$$

One gram of salt combines with 2.906 grams of silver nitrate.

Twenty-nine and six one-hundredths grams of silver nitrate are made up in solution to a volume of 1000 cc., or a liter. Now 10 cc. of the salt and curd solution used in the Kohman analysis represents one-tenth of the original 10 grams of butter. This contains the salt in 1 gram of the butter being analyzed. One cc. of the silver-nitrate solution has $\frac{1}{1000}$ of 29.06 grams, or 0.02906 grams silver nitrate, which combines with 0.01 gram of salt. This is 1 per cent of 1 gram of salt. Therefore, 1 cc. of the silver-nitrate solution represents 1 per cent of salt. Accordingly 2 cc. of silver nitrate represents 2 per cent of salt, etc.

NOTE: Some directions call for the metal-cup contents in a solution of 250 cc. These directions call for the use of a 25-cc. pipette. The volumetric flask and the larger pipette cost more. A 100-cc. graduate cylinder and a 10-cc. pipette are less expensive.

Short Cutting Kohman Analysis. Proceed as directed under regular Kohman method. Do not wash out fat with gasoline.

Measure 100 cc. of distilled water directly into metal cup after recording moisture reading. Now proceed to make the salt test as previously directed and record reading.

Be sure to heat the fat-salt-water mixture 115° to 130° F. and pour twenty times. Pouring is essential, or salt tests will be too low

Record of results:

Moisture	16.0%
Salt	2.4%
Curd (estimated)	1.0%
Moisture, salt, and curd	19.4%
Fat (100—19.4)	80.6%
Total	100.0%

NOTE: If a 250-cc. flask is used, measure 250 cc. of distilled water and transfer to a pint bottle. Now transfer from the pint bottle small portions of the distilled water to the metal cup containing the residue of the moisture test. Heat each portion in the metal cup and transfer to the 250-cc. flask. Shake the contents of the partly filled flask well and then transfer the rest of the water from the pint bottle to the flask. Allow a minute for the fat to rise and then use 25 cc. of this solution for the salt test.

Farrington or Rapid Acidity Test. Professor E. H. Farrington of the University of Wisconsin developed alkali tablets which contained the phenolphthalein indicator. These were first used in

1894. Two tablets were dissolved in an ounce of distilled water. Equal amounts of solution and milk or cream were used. If the milk or cream remained pink, its acidity was less than 0.2 per cent.

Recently, so-called giant Farrington tablets have been offered for sale in connection with compliance with cream-grading laws which set 0.6 per cent acidity as the dividing line between No. 1 and No. 2 cream. They are tablets made by the Griffith Laboratories, Chicago, Ill., dissolved at the rate of 1 tablet to 1 pint of distilled water. Equal portions of solution and cream are used.

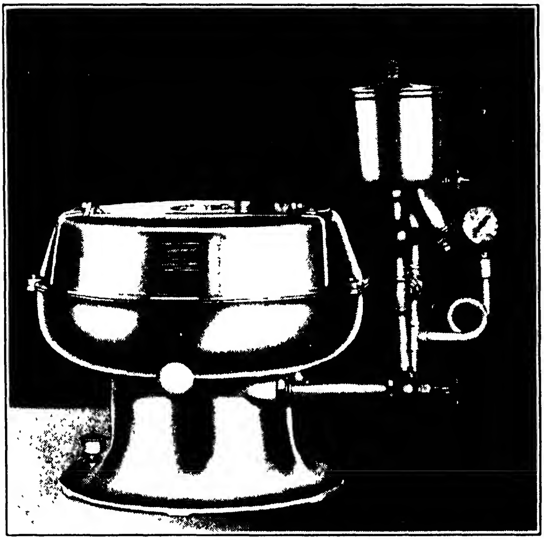

FIG. 103A. Modern steam-driven tester.

If the cream remains pink, it has less than 0.2 per cent acid. In using 0.6 per cent acidity as the dividing line, three portions of alkali solution are used to 1 portion of cream. If the solution remains pink, it is classed as No. 1 cream if otherwise meeting the requirements of that grade.

The common $N/10$ sodium-hydroxide solution used in creameries may be used for rapid acidity tests by making 100 cc. of this solution to a volume of 450 cc. including 10 cc. of ordinary phenolphthalein indicator. The pink color remaining in one portion of cream to which three portions of this solution have been added indicates less than 0.6 per cent acidity in the cream.

Experience in the use of these rapid acidity-test solutions made from tablets indicates that they are not entirely satisfactory. The solutions weaken on standing. Distilled water may not be used. Many cream buyers do not realize the need for accuracy in making solutions. These tablet solutions are being used quite extensively, however. A letter from the Minnesota Department of Agriculture [6] states that the department has favored and encouraged the use of the standard $N/10$ sodium-hydroxide solution and has found it more reliable.

Composite Samples. Composite samples of milk and cream are occasionally used in creameries. It is best not to carry them more than 7 to 10 days. They should be kept well stoppered and in a cool place. A proportionate amount of each delivery by one patron is placed in the sample bottle and mixed each time with the preservative and contents of the bottle.

The preservatives used are:

1. Bichloride of mercury.
2. Potassium dichromate.
3. Formalin.

Directions for use accompany the materials. Composite samples save time required for daily testing. They are quite suitable where payments for milk and cream are made periodically instead of for each delivery. The composite samples are tested in the usual manner of testing milk and cream except that care must be taken to see that they are warmed to 95° to 100° F. This temperature melts or loosens fat which may adhere to the sides of the bottle. Pour these samples for thorough mixing. Pipette at once, as fat may rise promptly. Cool the milk in the test bottles in cold water before adding acid. Charred fat tests will result unless this precaution is observed.

Use and Accuracy of Composite Cream Samples. Questions are frequently raised regarding the accuracy of results in testing composite samples, even when accurately taken. Combs, Thurston, Groth, and Coulter [7] made surveys and studies of the use and accuracy of composite cream samples. In creameries using composite samples, 89 per cent used bichloride of mercury as the preservative. Eighty per cent tested every 2 weeks, 12 per cent every 4 weeks, 3.4 per cent once per week, and 1.4 per cent twice a month

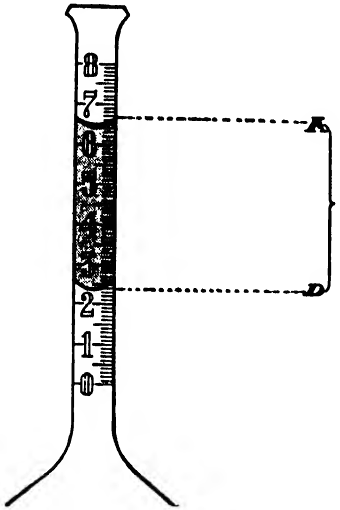

Fig. 104. Reading milk tests. In reading the percentage of fat in the milk test, the meniscus should be included, the reading being made from the extreme bottom of the lower meniscus, at the point *D*, to the extreme top of the upper meniscus, at the point *A*. The points of the dividers are placed at the upper and lower limits, then lowered until one point is at the zero mark; the other point will indicate on the scale the correct percentage for the sample tested. Do not use Glymol on milk tests.

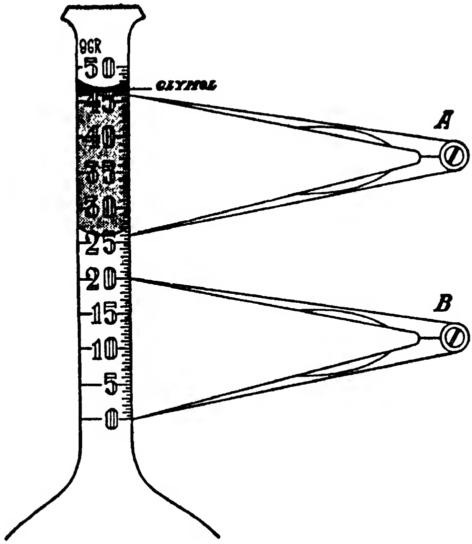

Fig. 104. Reading cream tests. Measure the fat column by arranging the dividers as indicated by position *A*. Then lower the dividers as indicated by position *B* and read the percentage directly.

Courtesy Kimble Glass Co.

in summer and once a month in winter. They found aliquot samples (proportional to the volume delivered) more accurate than dipper samples. Loss in weight by evaporation is shown by the following table.

LOSS IN WEIGHT OF COMPOSITE CREAM SAMPLES

100-GRAM SAMPLES—STORED TWO WEEKS

(Minn. Bull. 243)

Temperature	Loss of weight of original 100-gram sample		
	Glass cork	Rubber cork	Common cork
	Per cent	Per cent	Per cent
85 to 110° F.	0.93	0.45	0.14
85 to 110° F.	2.71	1.16	0.39
85 to 110° F.	4.40	1.18	0.36
70° F.	0.16	0.14	0.08
40° F.	0.02	0.01	0.07

It will be noted that high storage temperatures are to be avoided. The loss of 4.4 grams in a 100-gram sample would change the test of 30 per cent cream by 1.38 per cent.

$$(100 - 4.4 = 95.6 \qquad \frac{100}{95.6} \times 30\% = 31.38\%)$$

Influence on overrun:

30% cream contains 30 lb. fat per 100 lb. cream.

31.38% (incorrect test) charges creamery with 31.38 lb. fat for each 100 lb. cream.

$1.235 \times 30 = 37.05$ actual pounds butter made (23.5% O. R.)

$37.05 - 31.38 = 5.67$ lb. butter (gain)

$$\frac{5.67}{31.38} = 0.1807, \text{ or } 18.07\% \text{ O. R.}$$

$23.5\% - 18.07\% = 5.43\%$ loss in O. R.

It is to be doubted if the average creamery operator realizes that a difference of 1.38 points in test causes a reduction from a normal 23.5 per cent overrun to a low of 18.07 per cent.

However, it must be noted that these computations are based on a case of greatest evaporation. Evaporation at 40° F. was negligible. Evaporation at 70° F. was slight (0.14 per cent) and would cause less error than variations in actual performance and reading of tests.

Figures in the Minnesota trials indicated that a patron may expect accurate tests on 60.8 per cent of his deliveries if composites are prepared in aliquot and on 45 per cent of his deliveries if the dipper is used. The authors indicate that composites cannot be condemned as taken in Minnesota.

However, very sour cream is received in warm weather in many sections. Sour cream is more difficult to sample correctly. If composite samples are taken, the operator should exercise great care to see that samples are taken, cared for, and tested properly.

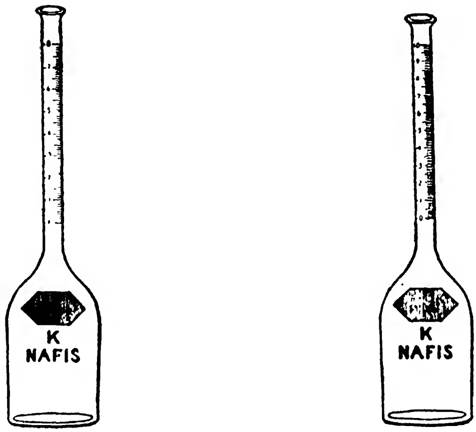

Fig. 105. Milk-test bottles. Left: 8 per cent, 18-gram bottle, graduated in tenths, reads more accurately because of wider spacing. Right: 10 per cent, 18-gram bottle, graduated in fifths, not official in some states. Courtesy Kimball Glass Co.

With any preservative, and especially when bichloride of mercury is used, samples should not be unduly agitated and should not be warmed above 100° F. when preparing samples for testing. Either factor increases the tendency to precipitate curd and accurate testing becomes increasingly difficult.

Composite sampling of cream is to be discouraged. When composite samples are taken, they must be held in tightly stoppered bottles and at as low temperatures as possible (but avoid freezing). Periods longer than 7 to 10 days are not recommendable.

Sediment Tests. *Sediment Test for Butter.* The following procedure is recommended by Meyers and Whittaker.[8]

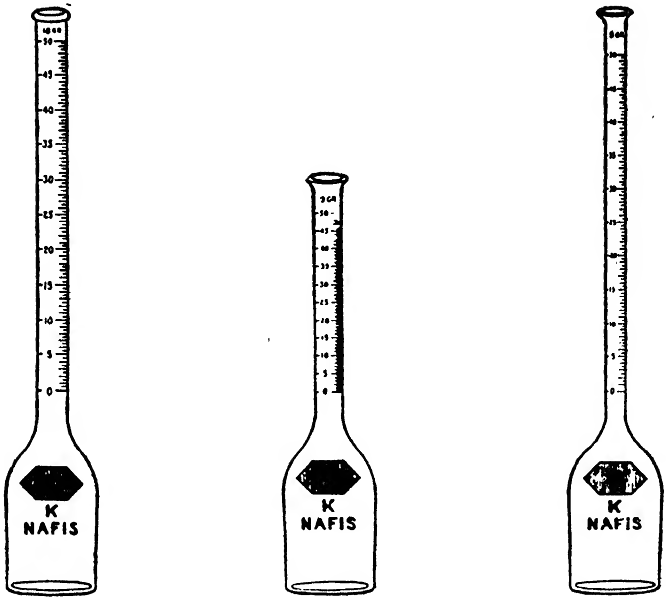

FIG. 106. Cream-test bottles. Left: 18-gram, 9-inch cream-test bottle. Center: 9-gram, 6-inch cream-test bottle. Right: 9-gram, 9-inch cream-test bottle. The 9-inch bottles require special centrifuges. The 9-inch, 9-gram bottle reads in tenths; the others in 0.5 per cent. Courtesy Kimball Glass Co.

1. Prepare a solution of either hydrochloric acid (concentrated 1.18 sp. gr.) or of sulphuric acid (concentrated as used in testing milk or cream).
   a. For hydrochloric acid, 4.5 cc. to 1000 cc. of filtered water.
   b. For sulphuric acid, 1.5 cc. to 1000 cc. of filtered water.
2. Use a 4-oz. sample of butter.
3. Use 8 oz. of the acid solution.
4. Heat to 160° F. to 180° F., preferably in a water bath, and filter.
5. Rinse the filter or sediment tester with clean filtered hot water to free the pad of fat.

The sediment testers for testing cream can be used for most samples of butter. Some butter may require more force to filter. Sediment testers of the vacuum type or the piston pressure type may be required. Filter discs should be about half the thickness of the common lintine disc used for milk sediment tests. The authors think nainsook, 100 × 100 mesh—strand size, 0.006 inch, is very good for filtering.

In comparison with the borax solution used early in 1934 by the Federal Pure Food Department the acid solutions give more rapid filtering on a greater number of samples. Some samples of butter filtered with difficulty by either method.

Sediment Test for Cream. Use four-ounce sample jars which are thoroughly clean. In taking samples at the intake, be sure to stir the cream thoroughly in order to get a proper portion of any heavy sediment which may have settled to the bottom of the patron's can.

Sediment tests are required in states having cream-grading laws. They must be made on each patron's cream at least once per month. If the tests are unsatisfactory, they must be repeated on each delivery of cream until satisfactory results are obtained. Near the close of the day's work the tests may be made on all samples received that day.

Place the 4-ounce sample of cream in the sediment tester.

If sweet or nearly so, add about one-half pint of hot water.

Filter and wash pad 2 or 3 times with hot water before removal from filter.

Place on cardboard with proper number or identification.

If cream is sour, add 3 or 4 drops of phenolphthalein indicator and add hot soda ash solution until a faint pink color remains after shaking.

Now add one-fourth to one-half pint of clean hot water and filter.

NOTES. Split sediment pads may be used if difficulty in filtering is experienced. Be sure the hot water and soda ash solution are filtered and free of sediment. Soda ash solution is made using one-half pound of soda ash per gallon of hot water. It must be kept hot for use.

Survey of Sediment Tests for Cream. A survey by the research committee of the American Association of Creamery Butter Manufacturers, reported by Stewart,[9] indicates that most satisfactory results in cream sediment testing were secured by the addition of hydrochloric acid to the cream. The test is described as follows:

2-ounce cream sample.
200 cc. $N/20$ HCl (4.5 cc. conc. HCl in 1000 cc. of water).
Shake and heat over water bath to 165° F.
Rince with 4 ounces or more of water at about 185° F.

The report does not specify the size of sediment pad used, but it may be assumed that it was the common lintine pad, which is 1¼ inches in diameter and affords a 1-inch filtering surface.

Four methods of making sediment tests were compared on all grades of cream and at all seasons of the year. Agricultural colleges and commercial creameries made the tests and reported to the laboratory of the American Association. Results showing the percentages of successful filtrations on 2-ounce cream samples are as follows:

COMPARISONS OF METHODS OF FILTERING CREAM

Method	Strength of solution	Amount used	Temperature of solution	Number of successful filtrations
acid	4.5 cc. conc. HCl per 1000 cc. water	200 cc.	165° F.	98%
ammonia	6 cc. sp. gr. 0.9 in 1000 cc. water	8 oz.	180° F.	88%
soda	2% $NaHCO_3$	8 oz.	180° F.	84%
lye	1% NaOH	9 cc.	185° F.	61%

There seems to be some lack of uniformity in the methods used in making sediment tests of cream. The procedure as set forth in the Iowa cream-grading law passed in 1935 is given here to help clarify the situation.

> 3100 G-14. Details of sediment test.—Test for sediment shall be made with either two or four ounces of cream. When made with two ounces, the sediment pad shall be one and one-fourth inches in diameter and have a filtering surface of one inch. When made with four ounces, the sediment pad or cloth shall have a strand thickness of six-thousandths of an inch and at least 100 threads to the inch, and a filtering surface of not more than one and one-half inches in diameter.

The Acidity Test. A $N/10$ solution of sodium hydroxide (NaOH) is used. Phenolphthalein, the indicator used, turns red in alkaline solutions and is colorless in acid media.

$$\underset{\text{sodium hydroxide}}{NaOH} + \underset{\text{lactic acid}}{CH_3CHOHCOOH} = \underset{\text{sodium lactate}}{CH_3CHOHCOONa} + \underset{\text{water}}{HOH}$$

Group weight of NaOH

$$23 + 16 + 1 = 40$$

Group weight of $H \cdot C_3H_5O_3$

$$1 + 36 + 5 + 48 = 90$$

These substances react chemically in exact proportions when in water solution and do so in the ratio of *40 grams* NaOH to *90 grams* $H \cdot C_3H_5O_3$. $N/10$ NaOH will have one-tenth of 40, or 4 grams per liter (1000 cc.). Each cubic centimeter of this solution has 0.004 gram.

Each cubic centimeter of $N/10$ NaOH required represents 0.009 gram of lactic acid. Therefore, we may use a formula:

$$\frac{\text{cc. } N/10 \text{ alk.} \times 0.009}{\text{grams of sample}} \times 100 = \text{per cent acidity}$$

For convenience we use 9 grams of milk, cream, whey, etc. as the sample tested. This simplifies the use of the formula thus:

$$\frac{4 \text{ cc. } N/10 \text{ alk.} \times \overset{0.001}{\cancel{0.009}}}{\underset{1.0}{\cancel{9}}} \times 100 = 0.40 \text{ per cent acidity}$$

assuming 4 cc. of $N/10$ NaOH was used in a test.

We see, then, that each cubic centimeter of alkali used is equivalent to 0.10 per cent acidity in the product tested.

Storch Test for Pasteurization. This test is applicable where pasteurization temperatures equal or exceed 80° C. (176.5° F.). Use 5 cc. of sample to be tested. Place in test tube. Add 1 drop of a 0.2 per cent solution of hydrogen peroxide. Add 2 drops of 2.0 per cent solution of paraphenylene diamine. Shake well.

Reading results:

a. Intense blue color means that sample has not been heated above 78° C., or has not been heated.

b. Blue-gray color within one-half minute indicates a heat treatment between 78° and 80° C.

c. No color change indicates that 80° C. has been exceeded.

Sensibility of test: An admixture of 10 per cent of cream heated to 78° C. will cause a color reaction in cream which was heated to 80° C. or more.

NOTE: Paraphenylene diamine will not remain active more than two months. Hydrogen peroxide should be stored in colored bottles and kept cool. Do not rely on solutions over 2 or 3 months old.

Application of the Storch Test to Butter. Zakariasen [10] uses the Storch test on butter as follows:

Heat sample of butter in water bath to 120° to 130° F. Tilt jar and pipette 5 cc. (curd portion) into test tube.
Add 5 cc. of water 120° to 130° F.
Add 2 drops of Storch reagent (0.2 per cent hydrogen peroxide).
Add 2 drops Storch indicator (2.0 per cent aqueous paraphenylendiamine hydrochloride). Mix thoroughly.

Observe color:

a. No color indicates that the cream from which the butter was made was pasteurized at 165° F. for 30 minutes, or that these conditions were exceeded.

b. An intense blue color indicates that the above conditions were not met.

Detection of Neutralized Cream. (J. I. Keith, Okla. Agricultural College, Stillwater, Okla. Ref: *Ice Cream Trade Journal,* Vol. 27, No. 8, p. 30, 1931.):

Procedure: Weigh 9 grams of cream into an Erlenmeyer flask or beaker.
Add 75 cc. distilled water.
Add 9 cc. $N/20$ HCl.
Mix thoroughly. Allow to stand 1 minute.

If cream has been neutralized to the extent of 0.1 per cent acid reduction, it will curdle, and a thin watery part separates out at the bottom.

Theory: Neutralizers in cream act as buffer salts and vary the amount of acid or alkali required to affect the acidity of the cream. The neutralizers prevent re-solution of the casein because of excessive acid added in the test.

The type of neutralizer does not affect the results.

NOTE: $N/20$ HCl may be made by using 4.2 cc. of concentrated HCl (sp. gr. 1.19) made up to 1000 cc., using distilled water. This solution should be checked for accuracy. The amounts of all ingredients should be exact.

The Determination of Yeasts and Molds in Butter. Total bacterial counts cannot logically be used in determining the general conditions surrounding the manufacture and handling of butter, because, frequently, cultures of specific organisms are added to the cream and, occasionally, directly to the butter itself, with the result that the bacterial content of the finished butter is thus influenced. Yeast and mold counts of butter have, accordingly, been suggested because these microorganisms should be present in very small numbers, if at all, in butter that is efficiently made from pasteurized cream and properly handled in thoroughly cleansed equipment. An essential part of laboratory control of butter quality is making yeast and mold counts of butter. The description of methods, outline of procedure, and interpretation of results given below are supplied by Dr. E. H. Parfitt of Purdue University. This is the standard used in their control work in Indiana.

Method of Taking the Sample. *Butter in the Churn.* After the butter has been worked and is ready to be removed from the churn, samples for microbiological analysis shall be taken by means of a sterile trier, taking three samples of about one-third ounce each, one from the center of the churn, and two from the respective ends.* The butter samples should then be placed in sterile jars with screw or glass top.

Tubs or Packages. A total of at least 1 ounce of butter should be removed from two different parts of the tub or package with a sterile trier, the plugs of butter being not less than 2 inches in length and including the surface portion. The butter should be transferred from the trier to the sterile sample jar with a sterile spatula or spoon.

* Under commercial conditions, where large numbers of samples must be taken daily, it may be impractical to employ a sterile trier for each sample. If a polished trier is wiped thoroughly with tissue paper after each sample until the surface is highly polished, dipped in ethyl alcohol, and the alcohol adhering to the trier set afire so as to burn off all the alcohol, and then the trier plunged into the butter to be sampled at least twice before the sample is taken, satisfactory results may be obtained with a single trier.

Print Butter. Because of difficulty in obtaining the same amount of exposed surface of butter on one, one-half, and quarter-pound prints, print butter should be sampled by means of a trier. By using a small trier and plugging the end of the print a plug of 3 to 4 inches may be obtained. Such a plug should weigh at least half an ounce. The butter should be transferred from the trier to a sterile sample jar with a sterile spatula or spoon.

Care of Samples. All samples, immediately after sampling, should be placed in cracked ice, or placed in a refrigerator where the temperature does not exceed 4° C., and plated as soon as possible.

Samples which are procured from a grading station remote from the laboratory should be stored at 4° C., or below, until shipped. At no time prior to analysis should samples of butter containing less than 10 per cent salt in the serum be permitted to exceed 4° C., nor samples of butter containing over 10 per cent to exceed 15.6° C.

For shipping, the samples should be cooled and packed carefully so as to prevent breakage and retain a low temperature. Upon receipt at the laboratory, the samples should be plated as soon as possible, and a record should be made of the days elapsed between sampling and plating.

Treatment of Equipment. Sterilization of glassware and equipment should correspond to Standards of Milk Analysis, American Public Health Association. Dilution bottles, media, etc., must be sterilized in the autoclave at 15 pounds (120° C.) for at least 20 minutes after the pressure reaches 15 pounds.

Metal triers, spatulas, and spoons should either be wrapped in paper (imported Kraft wrapping paper usually withstands sterilization temperatures without charring), or be enclosed in metal or glass containers, and sterilized in the same manner as glassware.

Wooden tongue depressors make satisfactory spatulas. They may be wrapped in paper or enclosed in a metal or glass container, and sterilized by autoclaving, or by hot air.

Equipment, Apparatus, and Reagents. These consist of:

Sterile screw-cap glass jars of suitable size.

Petri dishes and covers (100 $\times$ 15 mm.).

Pipettes (1.1 ml. and 10 ml. in 1/10ths).

Water blanks (90 ml.).
Sterile potato dextrose agar (Bacto or equivalent).
Sterile U.S.P. tartaric acid solution (10 per cent).
Water bath (45° C.).
Incubator (21-25° C.).
Autoclave.
Potentiometer for electrometric *p*H determinations, or spot plate and brom phenol blue indicator solution for colorimetric determinations.

Preparation of Potato Dextrose Agar. Place 200 grams of freshly peeled and sliced potatoes in 1000 milliliters distilled water. Boil for one hour, and then strain through double thicknesses of clean cheese cloth. Restore to original volume; add 20 grams of commercial dextrose, 15 grams agar-agar, and dissolve by autoclaving at 15 pounds pressure for 20 minutes. Filter through cotton; dispense in flasks in definite quantities; and sterilize at 15 pounds pressure for 20 minutes.

Add to the melted, sterile potato dextrose agar (just prior to pouring) sufficient sterile tartaric acid to give a reaction of *p*H 3.5 ± 0.1. Do not heat the agar after the addition of the acid, as heating at *p*H 3.5 may destroy the jellying properties of the agar.

The amount of tartaric acid to be added varies according to the buffering qualities of the medium—usually about 2.0 to 3.0 milliliters of 10 per cent U.S.P. tartaric acid per 100 milliliters of medium. The amount of tartaric acid necessary for acidulation to *p*H 3.5 must be determined for each batch of medium, using electrometric or colorimetric procedure. The final *p*H is to be 3.5 ± 0.1 at 21° C. A yellow-green color is obtained when using brom phenol blue in the colorimetric procedure.

Preparation of Dilutions. Warm the sample of butter contained in the sterile jar, as well as a sterile water blank, to about 40° C., in a water bath of 43-45° C. The time required for melting the butter should not exceed 15 minutes. Agitate thoroughly so as to obtain uniform mixing of the serum, water, and fat, and, with a previously warmed and wetted sterile 10 milliliter pipette, wetted by rinsing in the sterile warm-water blank, transfer 10 milliliters of butter to a 90-milliliter sterile water blank, the water in which is at 37-40° C. (Eleven milliliters of butter may be added to 99 milliliters of water.) Shake this dilution 25 times in the usual manner just before inoculating Petri dishes with the different dilutions in duplicate. The suggested dilutions are: 1 : 2 (5 milliliters of the 1 : 10 dilution); 1 : 10 (1 milliliter of the 1 : 10 dilution); and 1 : 100 (0.1 milliliter of the 1 : 10 dilution).

Incubation and Colony Counting. The Petri dishes containing the different solutions are flooded with the melted, adjusted potato dextrose agar. Incidentally, not more than 30 minutes should elapse from the time of making dilutions to the pouring of the plates. After solidification of the agar the plates are incubated for 5 days at 21-25° C.

At the end of the incubation period, count the colonies in the same manner as counting bacterial colonies in the plate count for milk, if interested only in the total yeast and mold count. Generally, it is desirable to differentiate between molds and yeasts. Make a separate count of the yeast colonies, which usually will be characterized as smooth, moist, elevated, surface colonies. After counting the typical yeast colonies, count the mold colonies. Mold colonies are easily recognized by their profuse growth of hyphae. Although the acidity of the medium is supposed to inhibit the growth of bacterial colonies, some may develop in spite of the acid. Usually these can be distinguished from the yeast colonies because they are smaller.

Reporting Results. The number of yeast and mold colonies per milliliter of butter should be reported as the total yeast and mold count, although, in control work, the separate yeast and mold counts are sometimes informative. The colony counts obtained from the 1 : 2 dilution (5 milliliters of the 1 : 10 dilution) will be multiplied by the factor 2, those from the 1 : 10 dilution (1 milliliter of the 1 : 10 dilution) by the factor 10, and those from the 1 : 100 dilution (0.1 milliliter of the 1 : 10 dilution) by the factor 100, to give the actual colony counts per milliliter of butter.

Standards. Different standards for acceptable total yeast and mold counts per milliliter of butter have been suggested by various laboratories. The following are tentative standards, based upon the results of actual creamery control work:

TOTAL YEAST AND MOLD COUNT PER MILLILITER OF BUTTER	SANITARY INDEX
Less than 50	Good
51–100	Fair
101–500	Poor
Over 500	Very poor

(Conclusion of Parfitt method.)

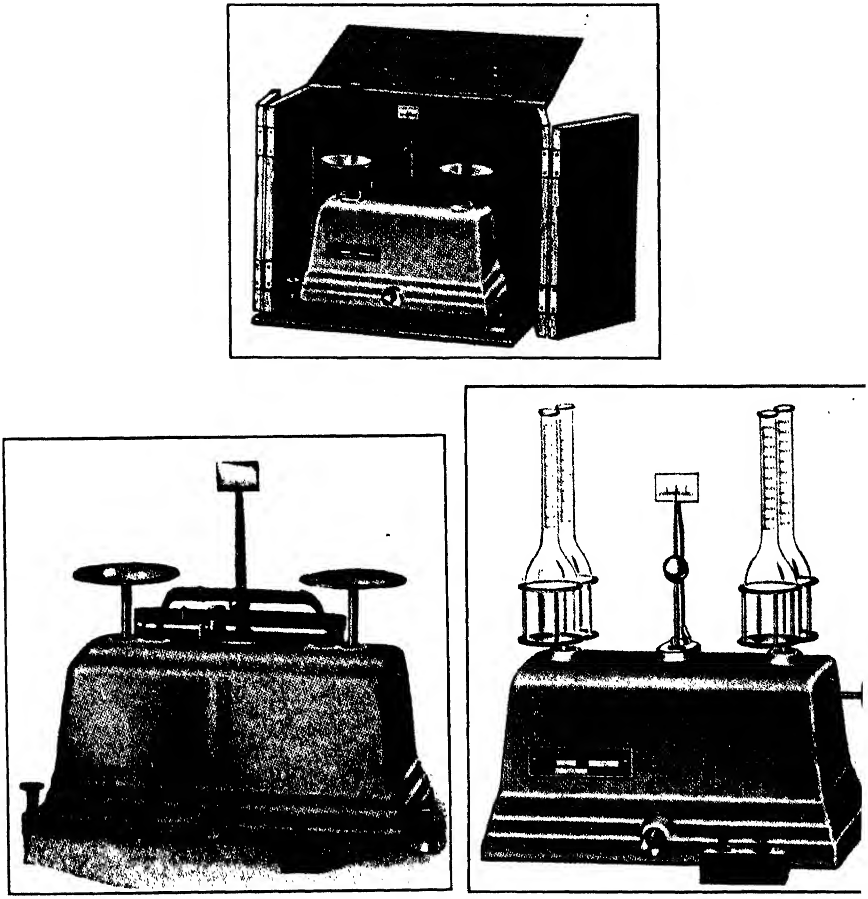

FIG. 107. Torsion folding case and windshield (top). (Drafts cause inaccurate weighing.) Butter moisture test scale (bottom left). Cream-test scale (bottom right). Courtesy Torsion Balance Co.

State Requirements for Test Bottles. It is very necessary to know state requirements for the kind of test bottles to use. The following table sets forth the regulations which were in force in

STATE REQUIREMENTS FOR TEST BOTTLES—1936.
(From Kimball Glass Co.)

	Milk Test Bottle	Cream Test Bottle	Testing Station	Charge
Ala.	8%	A B C		
Ariz.	8%	A C	State Dairy Com., Phoenix	$1.00 doz.
Ark.	any type	any type		
Calif.	8%	A C	Dairy Lab., Div. Chem., Sacramento	$1.00 doz.
Colo.	8%	A B C		
Conn.*	8%	A B C	Agr. Exp. Station, New Haven	none
Del.	8%	A B C	State Board Agr., Dover	none
Fla.	any type	any type		
Ga.	8%	A B C		
Idaho	8%	A B C	Dairy Dept., U. of Idaho, Moscow	3¢
Ill.	any type	any type		
Ind.	8%	B C	Agr. Exp. Sta., License Div., Lafayette	3¢
Iowa	any type	any type		
Kan.	8%	B	State Dairy Com., Topeka	none
Ky.	8%	B C	U. of Ky., License Div., Lexington	3¢
La.	8%	B C		
Me.	8% or 10%	A B C	Agr. Exp. Sta., Orono	5¢
Md.	any type	any type		
Mass.	8%	B	Agr. Exp. Sta., Amherst	5¢
Mich.	8%	B C	State Dept. Agr., Lansing	none
Minn.	8%	A B C		
Miss.	8%	A B C		
Mo. *		B		
Mont.*	8%	A B C		
Neb.*	8% or 10%		U. of Nebr., Dairy Dept., Lincoln	3¢
Nev.	8% or 10%		Food and Drug Com., Reno	$1.00 doz.
N. H.	8%	B	Dairy Dept., U. of N. H., Durham	5¢
N. J.	8%	B C	Agr. Exp. Sta., New Brunswick	5¢
N. M.	8%	A B C		
N. Y.	8%	A B C	Agr. Exp. Sta., Geneva	5¢
N. C. *	8%	A B C		
N. Dak.	8%	A B C		
Ohio	any type	any type		
Okla.	10%	A B C		
Ore.	8%	A B C	Dairy Dept., Agr. Col., Corvallis	3¢
Pa.	8%	A B C	Bur. Stand., Dept. Int. Affairs, Harrisburg	none
R. I.	8%	A B C	State Dept. Agr., Providence	5¢
S. C.	8%	A B C		
S. Dak.	8% or 10%	A B C		
Tenn.	8%	B C	State Dept. Agr., Nashville	3¢
Tex.	any type	any type		
Utah	any type	any type		
Vt.	8% or 10%	A B C	Agr. Exp. Sta., Burlington	3¢
Va.	8% or 10%	A B C	State Dairy and Food Dept., Richmond	5¢
Wash.	8%	A B C		
W. Va.	8%	A C		
Wis.	10%			
Wyo.	any type	any type		
Canada	any type	any type	Dept. Trade and Commerce, Ottawa	5¢

A = 18-gram, 9-inch, 50%, in ½ per cent. B = 9-gram, 6½-inch, 50%, in ½ per cent.
C = 9-gram, 9-inch, 50%, in ½ per cent. * = Recommended type. Other types may be used.

1936. Some states require all milk and cream testing glassware to be checked officially within the state before it may be released to dairy plants.

Wisconsin requires all 18-gram bottles graduated to 0.5 per cent. May be 6-inch, or 9-inch, or 6 to 9 in height.

Most supply houses have lists of state requirements and can be relied upon to ship glassware of the proper specifications. In case of doubt, correspond with the proper authorities in your state before placing orders.

Calibration of Testing Glassware. There are two methods of testing the accuracy of glassware for the Babcock test.

1. Brass plunger or Trowbridge calibrator.
2. Volumetric method.

The Trowbridge calibrator is a brass plunger which is inserted in the neck of a test bottle after it is filled to the zero mark. Colored alcohol is satisfactory to use to fill the bottles, although mercury may be used. A plunger of exact dimensions is designed for each type of test bottle. If we consider a 9-gram, 50 per cent cream-test bottle, the plunger will raise the liquid from the zero mark to the 50 per cent mark when it is fully immersed. The plunger will displace 5 cc. of the liquid.

If the liquid does not rise to the 50 per cent mark, the test bottle will cause fat tests to be read too low, and vice versa.

The Trowbridge calibration method is rapid but not so reliable as volumetric determination.

Volumetric method. Fill the test bottle to the zero mark with colored alcohol. Now run colored alcohol from a small bore burette into the test bottle until the top mark is reached. Proceed slowly so that any liquid touching the sides of the bottle neck will have drained to the liquid below. Read the burette before and after filling the bottle, and determine if more or less alcohol was used than is required for the particular bottle being tested.

See pp. 392, 394 for list of the cubic volume required in various test bottles, together with the method of calculation. The volume given is that which is required to fill exactly the space from the zero mark to the upper limit mark.

Origin of Cubic Centimeter and Gram. Believing that many creamery employees are not familiar with the significance of the

WEIGHT OF FAT AND CUBIC VOLUME OF SCALE ON TEST BOTTLES

Kind of bottle	Markings on bottle, per cent	Weight of product required, grams	Weight of fat in completely filled neck, grams	Volume of neck, cubic centimeters
A—milk test.....	0 to 8	18	1.44	1.6
B—milk test.....	0 to 10	18	1.80	2.0
C—cream test....	0 to 50	18	9.00	10.0
D—cream test...	0 to 50	9	4.50	5.0

A — 8% of 18.0 grams = 1.44 grams
Specific gravity of butterfat at 130° F. is 0.9.
1.44 grams is equivalent to 9/10 of required volume of completely filled bottle neck.
1/10 of filled neck = 1/9 of 1.44, or 0.16 cc.
10/10 (filled neck) = 10 × 0.16 cc., or 1 6 cc.
C— 50% of 18 grams = 9 grams.
(sp. gr. of butterfat = 0.9)
9 grams is equivalent to 9/10 of required volume of neck.
1/10 = 1/9 × 9, or 1 cc.
10/10 = 10 × 1 cc., or 10 cc.

terms of the metric system as used in the testing of dairy products, we explain briefly their origin.

At the outset it should be stated that the metric system of weights and measures is used by most countries except England and the British Dominions and the United States. The system is based on decimals, and calculations are rapid and exact. England and its colonies use the old English system of money, viz., pounds, shillings, and pennies. Three columns of figures are carried on each side of the ledger, or a total of six. Pennies are converted to shillings, and shillings to pounds. The monetary system of the United States is on the decimal basis, and calculations are enormously simplified.

The basis of the metric system is the meter, which is a fraction of the earth's circumference (about one ten millionth). A platinum bar, one meter in length, is stored in a vault in Paris. Its length is 39.37 inches. It is divided into tenths, hundredths, etc.

Weight measurement is based directly on linear measurement units. One cubic centimeter of water is exactly balanced, and the weight required to balance is termed a gram. The water is balanced under the following conditions:

a. Pure distilled water.

b. Point of greatest density of water (4° C. or 39° F.).

In testing we have the following direct application:

1 cc. of pure water weighs 1 gram.
1000 cc. (1 liter) of pure water weighs 1000 grams.
1000 cc. (1 liter) of milk (60° F.) weighs 1032 grams.

Therefore milk is 1.032 times heavier than pure water. This is known as its specific gravity. This information is used in lactometer testing of milk to determine adulteration with water or skim milk. (See Fig. 108.)

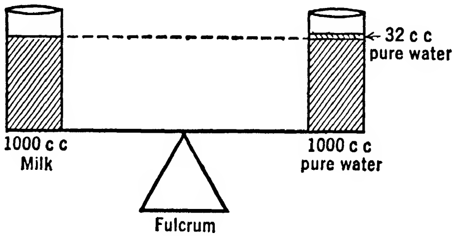

Fig. 108. Comparative specific gravity of milk and pure water illustrated. Notice that an exact balance is obtained when 32 additional cubic centimeters of water are used. Milk is the heavier (1.032 times).

Application in milk testing:
17.6 cc. pipette delivers 17.5 cc. of milk
$17.5 \times 1.032 = 18.06$ grams

A milk test requires 18 grams for testing. The 0.06 gram fraction is insignificant. It may or may not be transferred to the test bottle, depending on the time the pipette is allowed to drain.

QUESTIONS

1. Discuss the importance of preparing accurate samples for testing.
2. Give three reasons why cream is weighed for testing.
3. Why is it not necessary to weigh a sample of milk for the testing?
4. Why are modifications of the Babcock test used when testing buttermilk?
5. Outline the procedure for making a Kohman analysis of butter.
6. Show with calculations why 29.06 grams of silver nitrate per liter of solution is used in the salt test for butter. Give chemical reactions of the test.
7. Where and why is there a need for a rapid and approximate acidity test, such as the Farrington test?
8. State some precautions to observe in making composite samples of milk or cream.
9. What are the purposes of sediment tests of cream and of butter?
10. Give the formula used for computing the percentage of acidity.
11. Why is a 9-gram sample of cream used in making the acidity test?
12. If cream is measured in a pipette, what may be causes of errors?
13. Calculate the grams of sodium hydroxide used in making an acidity test of cream showing 0.70 per cent acidity (9-gram sample of cream).
14. What are the most probable uses of Keith's test for neutralized cream?

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CHAPTER 20

STARTING A LOCAL CREAMERY

In selecting a location to start a creamery, the same general considerations of all business ventures must be studied. Some of these as related particularly to the creamery business are:

1. The need for a new marketing agency; can greater profits be returned to producer.
2. The number and kind of present cream-marketing agencies.
3. The number of cows and the amount of cream produced.
4. Conservative estimate of volume of cream obtainable as in competition with existing marketing agencies.
5. Volume essential for success.
6. Future of town and dairy development.
7. Type of creamery and its cost.
8. Cost of creamery equipment.
9. Attitude of business men and farmers.

The need for a creamery must be determined by a survey of the sentiment and attitude of the people in a particular community. They must be presented with logical facts that point to such need. There must not be too much conflicting opinion presented by either business men or farmers.

The individual or the organization which is to sponsor the new enterprise must have knowledge of the essentials of success. There must be at least one individual who has had practical experience in the operation of a creamery who shall pass judgment on all factors before the enterprise is undertaken.

A minimum of 100,000 pounds of butterfat per year was formerly considered to be essential for success. This represents about 300,000 pounds of cream, and 500 to 700 cows will be required to produce this amount. Under present conditions it is unwise to consider less than *twice this amount of butterfat.* Roads, highways, and trucking facilities have so altered conditions that cream moves

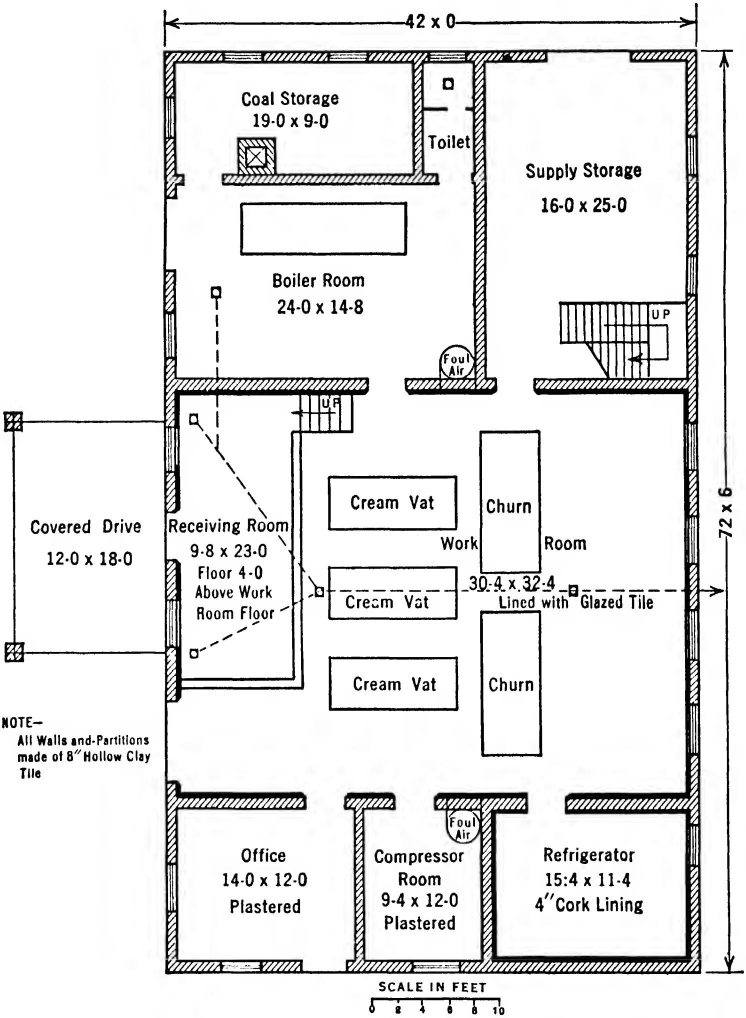

FIG. 109. A good floor plan for a local creamery. Office and receiving room close. Sales room might replace compressor room. Greeley Creamery, Greeley, Iowa. From Iowa Bull. 267, 1930.

freely and promptly and competitive conditions are often very hazardous. In areas where whole milk is bought and considerable portions are used for butter it is advisable to secure a daily aver-

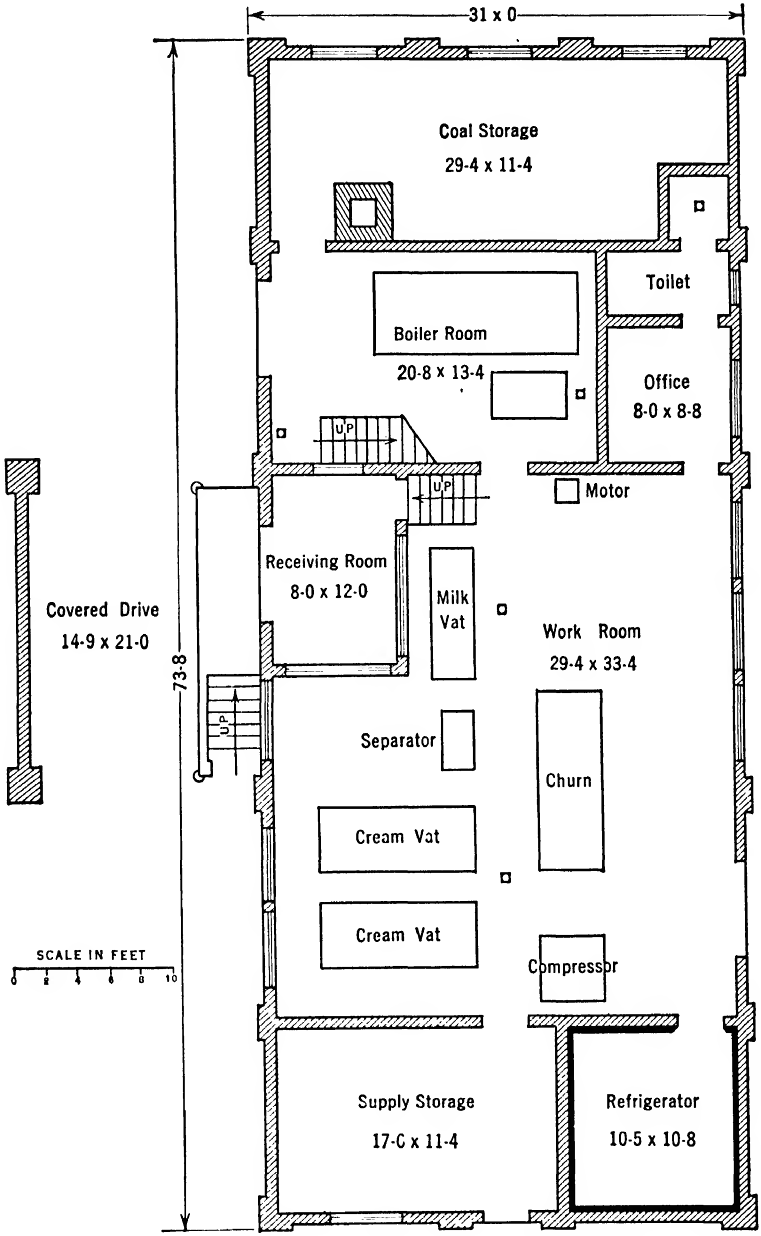

FIG. 110. Long narrow building causes extra steps. Office should be near receiving room. Sumner Creamery, Sumner, Iowa. From Iowa Bull. 267, 1930.

age of about 30,000 pounds of milk. Much depends on uses of milk for purposes other than the manufacture of butter.

To ascertain the amount of butterfat marketed at a given point, the best guide is figures on cream shipments from railway and express companies. Considerable unrecorded trucking of cream at the present time makes determinations less complete and estimates may be misleading. Every effort should be made to get figures which are reasonably accurate in order to make a decision. The element of chance will still play a part as it does in many business undertakings.

The location of neighboring creameries must be considered. The radius of operation of creameries has been definitely enlarged in the past five years because of cream-truck routes. Some of these creameries are well financed and have operated successfully for years. It is very probable that a new creamery would be compelled to operate truck routes from the beginning, and greater volume of cream must be secured if trucking costs are to be paid. Such costs usually range from 1 to 2 cents per pound of butterfat.

If new plants are to be established in sections where there are condenseries or cheese factories, or in market milk sheds, a very different problem is encountered. It is unwise to attempt the operation of a plant for buttermaking only. Procurement prices of butterfat are prohibitive. A new plant must be adequately financed, must be capably managed, and must of necessity be prepared to turn milk or cream into manufactured products which yield greater returns than the manufacture of butter.

A volume requisite for successful operation is difficult to establish. Thirty thousand pounds of milk daily, as suggested above, are equivalent to 500,000 to 700,000 pounds of butter, if all is utilized for that purpose.

A survey of the dairy plants in Wisconsin shows market milk-receiving stations and milk plants along the lake territory contiguous to the Wisconsin cities and Chicago. Further west in the central part are many cheese factories, and along the western border there are greater numbers of creameries. Condenseries are scattered throughout the central and eastern sections.

A survey of the status and trends of the dairy industry in New York State is interesting. A total of about 13,000,000 people concentrated in many large cities necessarily means that milk produced in the state is used largely as market milk. The number of cows has changed but little in 50 years, ranging from 1,300,000 to 1,500,000. New York dropped from first place to second in cheese production between 1890 and 1900. Creamery butter production has decreased greatly in the past forty years and New York now ranks in twenty-second place with about 14,000,000 pounds per year. R. L. Gillett of the New York State Department

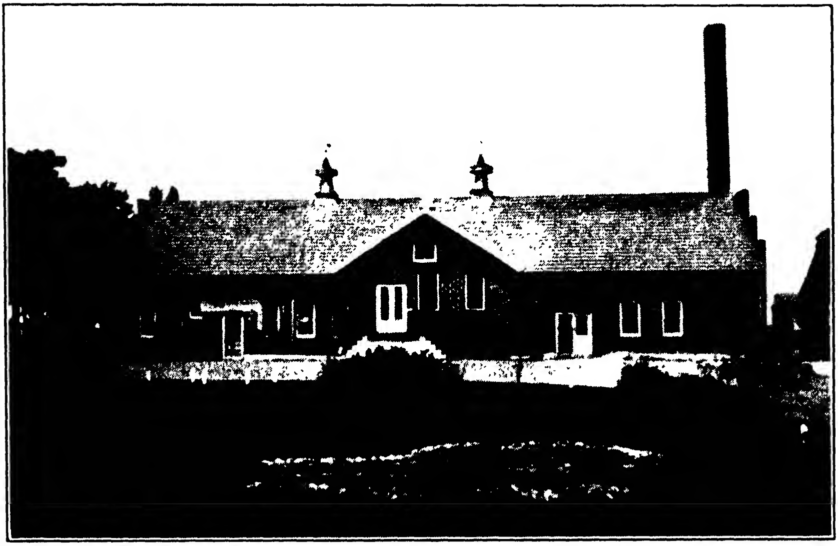

FIG. 111. The Hubbard Creamery, Hubbard Iowa. A substantial building, neatly landscaped. A pride to the owners and the community.

of Agriculture and Markets (personal correspondence) states that butter manufacture in New York is rather incidental, i.e., milk and cream may be made into butter if other outlets are temporarily dull. Only a few plants receive farm-skimmed cream directly from farmers. Such cream is frequently shipped far and is from farms unsuited to the sale of fluid milk. Likewise the number of cheese factories making cheese only has greatly declined. Many plants formerly listed as cheese factories have for many years shipped fluid milk in the fall and made cheese at times of surplus milk production.

The following figures from Bulletin 313 of the New York Department of Agriculture and Markets indicate the trend in number and kind of dairy plants.

LARGER PLANTS IN NEW YORK

Year	No. of plants reporting	Receiving from farmers		Manufacturing or selling			
		Milk	Cream	Whey butter	Creamery butter	American cheese	Cream for manufacture
1935	912	901	52	29	137	148	...
1934	1195	1182	90	51	163	179	230
1933	1246	1231	96	52	178	182	244
1932	1326	1307	86	48	127	153	146
1931	1399	1379	80	44	134	167	161
1930	1442	1417	84	53	135	221	162
1929	1373	1347	82	77	114	266	133
1928	1406	1377	98	92	132	272	131
1927	1330	1293	113	107	154	276	138
1926	1333	1294	123	110	161	312	153
1925	1340	1302	129	108	180	337	145
1924	1326	1285	134	...	247	410	...
1923	1329	1297	130	...	325	413	...
1922	1303	....	...	...	373	454	...

These statements and figures are given to show trends in New York and Wisconsin because they represent two states where the dairy industry is of major importance in agriculture and because they represent two distinct sections of the United States.

Location of Creamery. Modern creameries should be located as near the business center of the town as possible. Retail of creamery produce is frequently a profitable part of the business. Modern creameries should be clean in every respect, and visitors should be welcome at all times. This constitutes an effective means of advertising.

The creamery should be located near a vacant lot or alley so that space is provided for side or rear-door cream delivery. The creamery front should be entirely presentable in all details.

In small towns, where water and sewage disposal may present individual problems, these questions must be fully considered.

Extra costs may be involved. Some cities require creamery cess-pools to be used before the wastes enter the city mains. These points must be investigated.

Size and Type of Building. A building 40 by 70 or 50 by 70 feet will provide ample space for a creamery making 500,000 to 750,000 pounds of butter annually. Naturally, the size of the lot will determine to some extent the dimensions of the building. It should be remembered that long, narrow buildings require extra steps and may require additional heat in winter. In the South more outside wall space is conducive to higher temperatures in

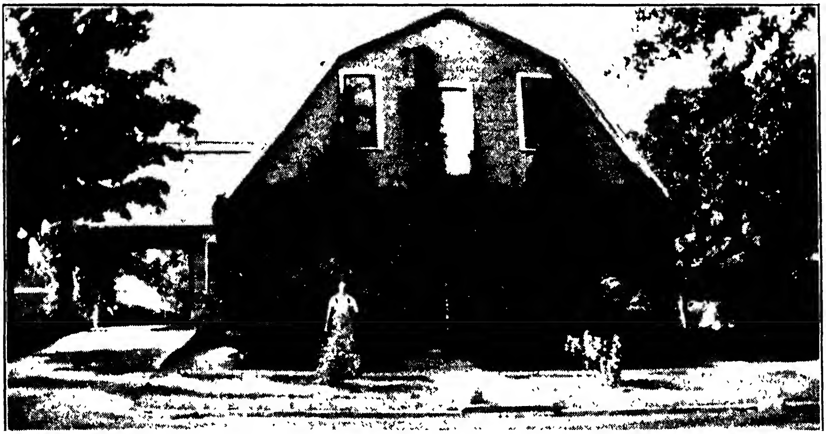

Fig. 112. Beck and Schwartz Creamery, Lancaster, Wisconsin. Well-cared for local creamery. Shrubs, vines, and flowers indicate pride in surroundings.

the creamery. Ceilings should be 12 to 14 feet. Where individual motors are used and shafting is not needed, a 12-foot ceiling may be very suitable. Motor operated ventilators may be provided in hot weather. Adequate ventilation is essential at all seasons of the year.

The creamery floor should have plenty of slope to drains, and drains should be at least 6 inches in diameter. Drain trouble is very perplexing and may be expensive. Floor slopes should be 3 inches to 12 feet, or one-fourth inch to the foot. Too frequently, insufficient slope is provided and the "water doesn't know which way to go." More slope also takes care of the possible depressions which may leave puddles.

Equipment. The following list of equipment, taken from "Essentials in the Success of a Local Cooperative Creamery," by

Fig. 113. Chatfield Cooperative Creamery, Chatfield, Minnesota. A substantial, well-designed local creamery. Modern ground-level intake with side entrance. Excellent chance for landscaping.

T. M. Olson and C. C. Totman in S. Dak. Bull. 266, 1931, is for a creamery making 200,000 to 400,000 pounds of butter annually:

1—1000 pound churn.
2—300 gallon cream vats.
1—5-ton compressor with other high compression side equipment.
1—Refrigerating room of approximately 160 sq. ft. floor space.
1—Brine tank and open-air coil.
1—Steam boiler—30 to 40 hp.
1—Intake cream scale.
1—Tub scale.
1—Babcock tester (24-bottle size).
1—Set glassware for tester.
1—Buttermilk tank (12 to 15 bbl.).

1—Butter-print table.
2—Wash sinks.
1—Brine pump.
1—Cream pump.
1—Butter-print stand.
12 to 20—Butter boxes (90-lb.), butter packer, and ladles.
1—Buttermilk pump or siphon.
1—4-wheel floor truck.
1—2-wheel barrel truck.
1—Cream-test scale.
1—Moisture-test scale and supplies.
1—Acidimeter.
1—Tub paraffiner.
1—Set cream sample jars, belts, shafting, hangers, pulleys.
1—7½-hp. motor for power.
1—7½-hp. motor for compressor.
1—30- to 50-gallon starter can.
1—Can rinser.
1—Office desk, chair, table, safe, adding machine, record books stationery. Other miscellaneous equipment and supplies, sanitary cream piping, tools, pails, cans, strainers, brushes, work bench, thermometers, acid measures, stirring rods, etc.

The cost of the above equipment at the present time would be approximately $10,000. The cost of installing must be added.

The cost of a suitable creamery building will range from $6000 to $12,000, depending upon the size, plan, materials used, and cost of labor. The total approximate cost of a suitable and permanent creamery building furnished with modern equipment, plumbing, ventilation, and refrigeration is about $18,000.

NOTE: Iowa Bull. 267, 1931, suggests $10,000 to $14,000 equipment costs (including all motorized equipment.)

QUESTIONS

1. List some factors to consider in selecting a location to start a creamery.
2. What is considered a minimum annual volume of butterfat for a successful creamery? Why?

3. Discuss creamery sites and internal and external appearance of buildings.
4. List the equipment required for a creamery manufacturing 200,000 to 400,000 pounds of butter per year. Give approximate costs of the major prices of equipment.
5. Draw a floor plan of a model creamery. Show location of equipment.

CHAPTER 21

STANDARDS AND DEFINITIONS

Legal requirements for dairy products entering interstate commerce are set forth in Acts of Congress. Supplementary regulations are provided from time to time based on interpretations of laws and interpretations of standards. The Food and Drug Administration, under the direction of the United States Department of Agriculture, has control of the enforcement of laws and regulations. Their work is chiefly concerned with goods which enter interstate commerce. However, at times they may take the initiative in cooperation with state inspections and regulatory officials and take an active part in condemning unfit foods. Such an instance is the active cooperation of federal and state officials in the condemnation and dumping of cream which is considered unfit for food and therefore unfit for the manufacture of butter. Although such cream may never enter interstate commerce, it may, if made into butter, enter interstate commerce and would then be under federal control.

Practically all states have laws covering standards and purity of foods, including dairy products. If state laws are incomplete in any detail, federal laws and regulations may become effective and thereby protect all consumers equally.

Of major importance to the butter industry is the law defining butter. This law is quoted from a letter from Dr. W. G. Campbell, chief of the Federal Food and Drug Administration, and is dated November 22, 1933. It is identical with the law passed by Congress in 1923. It reads: *Butter is the food product, usually known as butter, and which is made exclusively from milk or cream or both, with or without common salt, and with or without additional coloring matter and contains not less than 80 per cent by weight of milk fat, all tolerances having been allowed for.*

The law contains no mention of a moisture limit and none has been enforced since about 1925. A law limiting moisture has never existed. The Internal Revenue Department interpreted the 1902 federal law and made a regulation that butter containing 16 per cent or more of moisture was considered adulterated. This regulation was enforced for a number of years prior to 1925. At that time a test case (Lynch-Tilden) was passed from the Minnesota Supreme Court to the United States Supreme Court, and the Court held that only the 80 per cent fat standard could be enforced. Butter for interstate trade may contain moisture in amounts above 16 per cent. The percentage of salt must be lower if moisture is increased, in order that 80 per cent of fat shall be retained. In the final analysis, the consumer is just as well off if he has butter with 17 per cent moisture and 1.5 per cent salt as he is with 15.5 per cent moisture and 3 per cent of salt. In any case, he has 80 per cent or more of milk fat. Formerly, butter with 80 per cent fat and less than 16 per cent moisture was considered legal if not otherwise adulterated. Some butter of 86 to 88 score was legally acceptable, therefore, whereas, as a matter of fact, some of the cream used in making such butter was unfit. The importance of pure cream rather supercedes the importance of a pound more or less of moisture or salt. No attempt is made here to minimize the importance of legal standards.

From a survey of the north central and near-by states in 1932, we present the following summary of the legal requirements for making and marketing butter in these states.*

Partial Survey of Butter Standards, 1932. Details of the survey are included in the appendix of this book (Appendix D).

Minnesota—80 per cent fat and *16 per cent moisture.* (Activities of the Dairy and Food Department are confined to the fat standard only.) The 24 per cent overrun law is enforced.

Iowa—80 per cent fat standard only. (Real value of the law is to see that the consumer gets full food value; slight moisture variations above or below 16 per cent are not important.)

Kansas—80 per cent fat standard only, since 1927. (Commissioner indicates that variations of moisture are inconsequential as long as 80 per cent fat is maintained.)

* C. C. Totman, "Legal Requirements for Butter," *The Creamery Journal,* February 1, 1932.

Illinois—80 per cent fat standard only. (16 per cent moisture standard abandoned in January, 1930.)

S. Dakota—80 per cent fat standard only.

Wisconsin—82.5 per cent of fat with a tolerance of 2.5 per cent.

N. Dakota—80 per cent fat and 16 per cent moisture limit. (State chemist and state commissioner believe a higher standard of butter is produced with the double standard.)

In 1924, 25 states had moisture standards of 16 per cent, Louisiana limited moisture to 15 per cent, and the District of Columbia had a 12 per cent limit.

In 1938 only about 11 states have moisture limit laws and replies from some state commissioners indicated that they used only the 80 per cent fat standard.

Partial Survey of Butter Standards, 1938. A survey in November, 1938, of some of the states producing the largest butter surpluses and of some of the eastern states which produce very little butter but consume large quantities indicates that most of them have the single 80 per cent fat standard only. Several states eliminated the moisture standard during 1937 and 1938.

It might be presumed that the consumers (the eastern states) would retain the moisture limit. The Federal Bureau of Dairy Industry (1936) lists several states which did retain the 16 per cent moisture standard. They were Connecticut, New Hampshire, New Jersey, Pennsylvania, Vermont, and West Virginia. However, the federal standard of 80 per cent fat only has considerable significance and, although any state has the power to set its own standards, it probably would have some difficulty in enforcement. Attempts at enforcement of a moisture limit by a consumer state would exclude a very large part of market butter and the net result would be to diminish the supply in that state. This would probably cause higher prices for butter. New York City had a 16 per cent standard for about four years (1928-1932) and then annulled it.

The trend to a uniform single fat standard is quite evident.

N. Dakota—Passed a regulation in September, 1938, eliminating the 16 per cent moisture standard. Eighty per cent of fat only is required in butter.

Missouri—Present 82½ per cent fat standard for butter is ignored by enforcement officials. It is contrary to the federal standard. Efforts are being concentrated on modernizing all the state dairy laws.

Vermont—80 per cent fat standard only. Little attention paid to moisture content. (State law limits moisture content to 16 per cent.)

Wisconsin—82½ per cent fat standard only. Law reads 82½ per cent of fat with a tolerance of 2½ per cent. Laws specifying 82½ per cent of fat usually have reference to the salt content. If salt is low, the fat requirement is higher.

New Jersey—80 per cent fat standard only is enforced in conformity with the federal standard.

Ohio—80 per cent fat standard only.

New York—80 per cent fat standard only.

New Hampshire—80 per cent fat standard and 16 per cent moisture. Former is enforced. Latter likely to be deleted in forthcoming legislative session, 1939. If deleted, hopes are that fat standard will be increased for unsalted butter.

Connecticut—80 per cent fat standard only.

Oklahoma—80 per cent fat only, by regulation and not a state law. No difficulty so far in enforcement of regulation.

Pennsylvania—80 per cent fat standard only. During September, 1938, a new law became effective which has no moisture standard.

Indiana—80 per cent fat standard only.

Iowa—80 per cent fat standard only.

Michigan—80 per cent fat standard only. The 1937 legislature removed the moisture standard.

Minnesota—80 per cent fat standard only. The 1937 legislature removed the old moisture standard.

Federal Standards for Dairy Products. The Food and Drug Insecticide Administration of the United States Department of Agriculture has drawn up definitions and standards for food products, which are here presented in full.

UNITED STATES DEPARTMENT OF AGRICULTURE
FOOD, DRUG, AND INSECTICIDE ADMINISTRATION

SERVICE AND REGULATORY ANNOUNCEMENTS

FOOD AND DRUG No. 2
(FIRST REVISION)
DECEMBER, 1928

DEFINITIONS AND STANDARDS FOR FOOD PRODUCTS

Milk and Milk Products

a. Milks

1. Milk is the whole, fresh, clean lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within 15 days before and 5 days after calving, or such longer period as may be necessary to render the milk practically colostrum free.

2. Pasteurized milk is milk that has been subjected to a temperature not lower than 145° F. for not less than 30 minutes, after which it is promptly cooled to 50° or lower.

3. Homogenized milk is milk that has been mechanically treated in such a manner as to alter its physical properties, with particular reference to the condition and appearance of the fat globules.

4. Skimmed milk is milk from which substantially all of the milk fat has been removed.

5. Buttermilk is the product that remains when fat is removed from milk or cream, sweet or sour, in the process of churning. It contains not less than 8.5 per cent of milk solids not fat.

6. Cultured buttermilk is the product obtained by souring pasteurized skimmed or partially skimmed milk by means of a suitable culture of lactic bacteria. It contains not less than 8.5 per cent of milk solids not fat.

7. Goat's milk, ewe's milk, etc., are the fresh, clean lacteal secretions, free from colostrum, obtained by the complete milking of healthy animals other than cows, properly fed and kept, and conform in name to the species of animal from which they are obtained.

8. Evaporated milk is the product resulting from the evaporation of a considerable portion of the water from milk, or from milk with adjustment, if necessary, of the ratio of fat to nonfat solids by the addition or by the abstraction of cream. It contains not less than 7.8 per cent of milk fat, nor less than 25.5 per cent of total milk solids, provided, however, that the sum of the percentages of milk fat and total milk solids be not less than 33.7.

9. Sweetened condensed milk is the product resulting from the evaporation of a considerable portion of the water from milk to which sugar (sucrose) has been added. It contains not less than 28 per cent of total milk solids, and not less than 8 per cent of milk fat.

10. Evaporated skimmed milk is the product resulting from the evaporation of a considerable portion of the water from skimmed milk, and contains not less than 20 per cent of milk solids.

11. Sweetened condensed skimmed milk is the product resulting from the evapora-

tion of a considerable portion of the water from skimmed milk to which sugar (sucrose) has been added. It contains not less than 24 per cent of milk solids.

12. Dried milk is the product resulting from the removal of water from milk, and contains not less than 26 per cent of milk fat, and not more than 5 per cent of moisture.

13. Dried skimmed milk is the product resulting from the removal of water from skimmed milk, and contains not more than 5 per cent of moisture.

14. Malted milk is the product made by combining whole milk with the liquid separated from a mash of ground barley malt and wheat flour, with or without the addition of sodium chloride, sodium bicarbonate, and potassium bicarbonate, in such a manner as to secure the full enzymic action of the malt extract, and by removing water. The resulting product contains not less than 7.5 per cent of butterfat and not more than 3.5 per cent of moisture.

b. Cream

1. Cream, sweet cream, is that portion of milk, rich in milk fat, which rises to the surface of milk on standing or is separated from it by centrifugal force. It is fresh and clean. It contains not less than 18 per cent of milk fat and not more than 0.2 per cent of acid-reacting substances, calculated in terms of lactic acid.

2. Whipping cream is cream which contains not less than 30 per cent of milk fat.

3. Homogenized cream is cream that has been mechanically treated in such a manner as to alter its physical properties, with particular reference to the condition and appearance of the fat globules.

4. Evaporated cream, clotted cream, is cream from which a considerable portion of water has been evaporated.

c. Milk Fat or Butterfat

1. Milk fat, butterfat, is the fat of milk.

d. Butter

1. By act of Congress approved March 4, 1923, butter was defined and the following standard provided for it: "That for the purposes of the Food and Drugs Act of June 30, 1906 (34th Statutes at Large, p. 768), 'butter' shall be understood to mean the food product usually known as butter, and which is made exclusively from milk or cream, or both, with or without common salt, and with or without additional coloring matter, and containing not less than 80 per centum by weight of milk fat, all tolerances having been allowed for."

e. Cheese

1. Cheese is the sound product made from curd obtained from the whole, partly skimmed, or skimmed milk of cows, or from the milk of other animals, with or without added cream, by coagulating the casein with rennet, lactic acid, or other suitable enzyme or acid, and with or without further treatment of the separated curd by heat or pressure, or by means of ripening ferments, special molds, or seasoning.

In the United States the name "cheese," unqualified, is understood to mean Cheddar cheese, American cheese, American Cheddar cheese.

2. Whole milk cheese is cheese made from whole milk.

3. Partly skimmed milk cheese is cheese made from partly skimmed milk.
4. Skimmed milk cheese is cheese made from skimmed milk.

Whole Milk Cheese

5. Cheddar cheese, American cheese, American Cheddar cheese, is the cheese made by the Cheddar process from heated and pressed curd obtained by the action of rennet on whole milk. It contains not more than 39 per cent of water, and, in the water-free substance, not less than 50 per cent of milk fat.

6. Stirred curd cheese, sweet curd cheese, is the cheese made by a modified Cheddar process from curd obtained by the action of rennet on whole milk. The special treatment of the curd, after the removal of the whey, yields a cheese of more open, granular texture than Cheddar cheese. It contains, in the water-free substance, not less than 50 per cent of milk fat.

7. Pineapple cheese is the cheese made by the pineapple Cheddar cheese process from pressed curd obtained by the action of rennet on whole milk. The curd is formed into a shape resembling a pineapple, with characteristic surface corrugations, and during the ripening period the cheese is thoroughly coated and rubbed with a suitable oil, with or without shellac. It contains, in the water-free substance, not less than 50 per cent of milk fat.

8. Limburger cheese is the cheese made by the Limburger process from unpressed curd obtained by the action of rennet on whole milk. The curd is ripened in a damp atmosphere by special fermentation. It contains, in the water-free substance, not less than 50 per cent of milk fat.

9. Brick cheese is the quick-ripened cheese made by the brick-cheese process from pressed curd obtained by the action of rennet on whole milk. It contains, in the water-free substance, not less than 50 per cent of milk fat.

10. Stilton cheese is the cheese made by the Stilton process from unpressed curd obtained by the action of rennet on whole milk, with or without added cream. During the ripening process a special blue-green mold develops, and the cheese thus acquires a marbled or mottled appearance in section.

11. Gouda cheese is the cheese made by the Gouda process from heated and pressed curd obtained by the action of rennet on whole milk. The rind is colored with saffron. It contains, in the water-free substance, not less than 45 per cent of milk fat.

12. Neufchatel cheese is the cheese made by the Neufchatel process from unheated curd obtained by the combined action of lactic fermentation and rennet on whole milk. The curd, drained by gravity and light pressure, is kneaded or worked into a butterlike consistence and pressed into forms for immediate consumption or for ripening. It contains, in the water-free substance, not less than 50 per cent of milk fat.

13. Cream cheese is the unripened cheese made by the Neufchatel process from whole milk enriched with cream. It contains, in the water-free substance, not less than 65 per cent of milk fat.

14. Roquefort cheese is the cheese made by the Roquefort process from unheated unpressed curd obtained by the action of rennet on the whole milk of sheep, with or without the addition of a small proportion of the milk of goats. The curd is inoculated with a special mold (*Penicillium roqueforti*) and ripens with the growth of the mold. The fully ripened cheese is friable and has a mottled or marbled appearance in section.

15. Gorgonzola cheese is the cheese made by the Gorgonzola process from curd obtained by the action of rennet on whole milk. The cheese ripens in a cool, moist

atmosphere with the development of a blue-green mold and thus acquires a mottled or marbled appearance in section.

Whole Milk or Partly Skimmed Milk Cheese

16. Edam cheese is the cheese made by the Edam process from heated and pressed curd obtained by the action of rennet on whole milk or on partly skimmed milk. It is commonly made in spherical form and coated with a suitable oil and a harmless red coloring matter.

17. Emmenthaler cheese, Swiss cheese, is the cheese made by the Emmenthaler process from heated and pressed curd obtained by the action of rennet on whole milk or on partly skimmed milk, and is ripened by special gas-producer bacteria, causing characteristic "eyes" or holes. The cheese is also known in the United States as "Schweizer." It contains, in the water-free substance, not less than 45 per cent of milk fat.

18. Camembert cheese is the cheese made by the Camembert process from unheated unpressed curd obtained by the action of rennet on whole milk or on slightly skimmed milk, and ripens with the growth of a special mold (*Penicillium camemberti*) on the outer surface. It contains, in the water-free substance, not less than 45 per cent of milk fat.

19. Brie cheese is the cheese made by the Brie process from unheated unpressed curd obtained by the action of rennet on whole milk, on milk with added cream, or on slightly skimmed milk, and ripens with the growth of a special mold on the outer surface.

20. Parmesan chee-e is the cheese made by the Parmesan process from heated and hard-pressed curd obtained by the action of rennet on partly skimmed milk. The cheese, during the long ripening process, is coated with a suitable oil.

Skimmed Milk Cheese

21. Cottage cheese, Schmierkase, is the unripened cheese made from unheated (or scalded) curd obtained by the action of lactic fermentation or lactic acid or rennet, or by any combination of these agents, on skimmed milk, with or without the addition of buttermilk. The drained curd is sometimes mixed with cream, salted, and sometimes otherwise seasoned.

Whey Cheese

22. Whey cheese (so-called) is produced by various processes from the constituents of whey. There are a number of varieties, each of which bears a distinctive name, according to the nature of the process by which it has been produced, as, for example, "Ricotta," "Zieger," "Primost," "Mysost."

Pasteurized Cheese and Emulsified Cheese

23. Pasteurized cheese, pasteurized-blended cheese, is the clean, sound, pasteurized product made by comminuting and mixing, with the aid of heat and water, one or more lots of cheese into a homogeneous, plastic mass. The name "pasteurized cheese," "pasteurized-blended cheese," unqualified, is understood to mean pasteurized Cheddar

cheese, pasteurized-blended Cheddar cheese, and applies to a product which conforms to the standard for Cheddar cheese. Pasteurized cheese, pasturized-blended cheese, bearing a varietal name, is made from cheese of the variety indicated by the name and conforms to the limits for fat and moisture for cheese of that variety.

24. Emulsified cheese, "process cheese," is the modified cheese made by comminuting and mixing one or more lots of cheese into a homogeneous, plastic mass, with the aid of heat, with or without the addition of water, and with the incorporation of not more than 3 per cent of a suitable emulsifying agent. The name "emulsified cheese," "process cheese," unqualified, is understood to mean emulsified Cheddar cheese, process Cheddar cheese, and applies to a product which contains not more than 40 per cent of water and, in the water-free substance, not less than 50 per cent of milk fat. Emulsified cheese, process cheese, qualified by a varietal name, is made from cheese of the variety indicated by the name, and conforms to the limits for fat and moisture for cheese of that variety.

f. Ice Cream

1. Ice cream is a frozen product made from cream and sugar, with or without a natural flavoring, and contains not less than 14 per cent of milk fat.

2. Fruit ice cream is a frozen product made from cream, sugar, and sound, clean, mature fruits, and contains not less than 12 per cent of milk fat.

3. Nut ice cream is a frozen product made from cream, sugar, and sound, non-rancid nuts, and contains not less than 12 per cent of milk fat.

g. Miscellaneous Milk Products

1. Whey is the product remaining after the removal of fat and casein from milk in the process of cheese making.

SERVICE AND REGULATORY ANNOUNCEMENTS
FOOD AND DRUG No. 2
(FIRST REVISION)

SUPPLEMENT No. 1.
REVISED AND AMENDED DEFINITIONS AND STANDARDS FOR FOOD PRODUCTS
ISSUED DECEMBER, 1929

(Quoted in part)

The following revised and amended definitions for food products are adopted:

1. Milk is the whole, fresh, clean lacteal secretion obtained by the complete milking of one or more healthy cows, excluding that obtained within 15 days before and 5 days after calving, or such longer period as may be necessary to render the milk practically colostrum free. The name "milk" unqualified means cow's milk.

2. Pasteurized milk is milk every particle of which has been subjected to a temperature not lower than 142° F. for not less than 30 minutes and then promptly cooled to 50° F. or lower.

4. Skim milk, skimmed milk, is that portion of milk which remains after removal of the cream in whole or in part.

7. Goat's milk and ewe's milk are the whole, fresh, clean lacteal secretions free from colostrum, obtained by the complete milking of the healthy animals and conform in name to the species of animal from which they are obtained.

The present definition for ice cream is deleted.

R. W. DUNLAP,
Acting Secretary of Agriculture

Washington, D. C., November 25, 1929
84796°—29

A table giving the legal standards of the common dairy products is presented on p. 417. These standards serve as a reliable guide but must not be taken as final at any subsequent date because they may be modified or amended by law or may be changed by official regulations in the several states.

Wis.—tolerance 2.5% fat in butter.

Where no serum solids minimum is given for milk, a total solids is specified.

w.f.s. = waterfree substance.

If 16% moisture in butter is specified as the standard, get in touch with your food officials, because such standard may not be enforced.

LEGAL STANDARDS FOR DAIRY PRODUCTS—1936

Bureau Dairy Industry (B. D. I. M. 583)

	Butter		Milk		Ice Cream		Cheese	
	Fat	Moisture	Fat	S. S.	Plain	Fruit Nut	Fat	Moisture
Federal	80	......	......	......	......	......	50% wfs	39
Ala.	80	16	3 25	8 5	10	8	30.5	39
Ariz.	80	16	3.25	8.5	10	8	50% wfs	39
Ark.	......	......	......	......	8	6	....	......
Calif.	80	......	3.30	8 5	10	8	50% wfs	38
Colo.	80	......	3 20	......	12	10	50% wfs	......
Conn.	80	16	3.25	8 5	10	8	....	......
Del.	......	......	3.25	8 5	12	10	....	......
District Columbia	80	......	3.50	8 0	8	8	....	......
Fla.	80	......	3 25	8 5	10	8	50% wfs	......
Ga.	80	......	3.25	8 5	10	8	50% wfs	39
Idaho	80	......	3 20	8 0	10	8	30%	......
Ill.	80	......	3 00	8 5	12	10	50% wfs	39
Ind.	80	......	3.25	8 5	10	8	50% wfs	39
Iowa	80	......	3.00	8 5	12	10	30%	......
Kan.	80	......	3.25	......	10	10	50% wfs	......
Ky.	80	16	3 25	8 0	10	10	50% wfs	39
La.	80	......	3 25	8 5	10	8	30%	......
Me.	......	......	3 25	8 5	14	12	50% wfs	......
Md.	80	......	3.50	......	12	8 to 10	50% wfs	......
Mass.	80	......	3 35	......	10	8	50% wfs	......
Mich.	80	16	3.00	8 5	12	10	50% wfs	40
Minn.	80	16	3 25	......	12	10	50% wfs	39
Miss.	80	......	3 00	8 5	10	8	50% wfs	39
Mo.	82 5	......	3.25	8 5	8	8	50% wfs	......
Mont.	80	......	3.25	8 5	10	9	50% wfs	39
Neb.	80	......	3.00	......	14	12	50% wfs	38
Nev.	80	......	3.25	8 5	14	12	50% wfs	......
N. H.	80	16	3.35	......	14	12	50% wfs	39
N. J.	80	16	3.00	......	10	8	50% wfs	......
N. Mex.	80	16	3.25	8.5	12	10	....	......
N. York	80	......	3 00	......	10	8	50% wfs	40
N. C.	80	16	3.25	8.5	10	8	50% wfs	......
N. Dak.	80	16	3 00	......	12	10	50% wfs	39
Ohio	80	......	3.00	......	10	8	30%	......
Okla.	80	16	3 50	8 5	12	10	....	......
Ore.	80	......	3.20	8.5	12	10	50% wfs	......
Pa.	80	16	3.25	......	10	8	32%	......
R. I.	80	......	3.25	......	8	8	50% wfs	39
S. C.	......	......	3.00	8 5	10	10	....	......
S. Dak.	80	......	3.25	8.5	12	10	50% wfs	......
Tenn.	80	......	3.50	8.5	8	6	....	......
Texas	......	......	......	......	8	6	50% wfs	39
Utah	80	......	3.20	8 3	12	9	50% wfs	39
Vt.	80	16	3.25	8 5	14	12	50% wfs	39
Va.	80	......	3.25	8 5	10	8	50% wfs	......
Wash.	80	......	3.25	8 5	10	10	50% wfs	......
W. Va.	80	16	3.00	8.5	8	......	50% wfs	......
Wis.	82.5	......	3.00	8 5	13	11	50% wfs	39
Wyo.	80	......	3.00	8 5	10	10	50% wfs	39

NOTE: North Dakota, Michigan, Minnesota, and Pennsylvania deleted moisture standards in 1937 and 1938.

CHAPTER 22

DAIRY PRODUCTION AND STATISTICS

In order that the student may have some conception of the development of the dairy industry and its importance in general agriculture, data are presented here in graphical form. We have confined our considerations to the major dairy products. The student will note that 20.4 per cent, or about one-fifth of the total farm income, in 1933 was from dairy products. As a source of farm income it is equaled only by "livestock and products, other than dairy and poultry." Not only does it assume huge proportions, but it should be remembered that this income to farmers is largely cash. This is of great economic significance. Income received from day to day or week to week may be more vital in farm life than receipts of larger amounts at irregular intervals.

A Challenge. This study of the magnitude of the industry should make each participant realize a very definite obligation to help maintain the highest standard of quality of dairy products. He should use every means available to improve quality both in his factory and at the source of raw materials. He should take every legitimate and ethical means of informing the public of the superior food value of dairy products. He should set an example in pride and appearance. He should never falter in his efforts to promote more sanitary and more efficient methods of manufacture. This constitutes a challenge to the ability and foresight of each individual in the industry.

The figures in the table prepared by W. F. Jensen show the intensity of creamery butter production in the various states. The figures for Iowa are noteworthy in the sense that they reveal a high production per acre. This means that Iowa has an unusually large amount of productive land. Her corn production is about the same as that of Illinois, and hog and dairy-cattle productions are far greater. Figures for 1936 from the Year Book of the Department

RELATION OF BUTTER PRODUCTION TO ACREAGE BY STATES

(Authority: W. F. Jensen, Statement before Committee on Agriculture, U. S. Senate and House of Representatives, March, 1935. From *American Creamery and Poultry Produce Review*, Vol. 81, p. 66, 1935. Paper by M. E. Parker.)

State	Total Land Area Acres	Creamery Butter Lb. Total	Production 1933 Lb. Per Acre
Minnesota	51,749,120	299,872,000	5.79
Iowa	35,575,040	239,125,000	6.72
Wisconsin	35,363,840	157,933,000	4.41
Nebraska	49,157,120	93,361,000	1.90
Missouri	43,985,280	86,138,000	1.96
Ohio	26,073,600	83,076,000	3.19
Kansas	52,335,360	81,969,000	1.56
Michigan	36,787,200	79,637,000	2.16
Indiana	23,068,800	76,508,000	3.32
California	99,617,280	76,194,000	.76
Illinois	35,867,520	68,106,000	1.90
North Dakota	44,917,120	50,799,000	1.13
South Dakota	49,195,520	43,393,000	.88
Oklahoma	44,424,960	39,280,000	.88
Texas	167,934,720	36,543,000	.22
Washington	42,775,040	34,146,000	.80
Idaho	53,346,560	29,420,000	.55
Oregon	61,188,480	27,308,000	.45
Colorado	66,341,120	23,909,000	.36
Kentucky	25,715,840	22,029,000	.86
Tennessee	26,679,680	17,433,000	.65
Montana	93,523,840	14,795,000	.16
Utah	52,597,760	12,754,000	.24
Mississippi	29,671,680	7,855,000	.26
Virginia	25,767,680	5,910,000	.23
Arkansas	37,584,000	3,247,000	.09
North Carolina	31,193,600	2,878,000	.09
Wyoming	62,430,720	2,464,000	.03
Alabama	32,818,560	2,404,000	.07
Louisiana	29,061,760	1,879,000	.06
New Mexico	78,401,920	952,000	.01
South Carolina	19,516,800	948,000	.05
West Virginia	15,374,080	454,000	.03

of Agriculture, United States, show dairy cattle in Iowa and Illinois in a 44 to 26 ratio, hogs in a 75 to 41 ratio, and butter in a 67 to 19 ratio. The total land area of the two states is about the same.

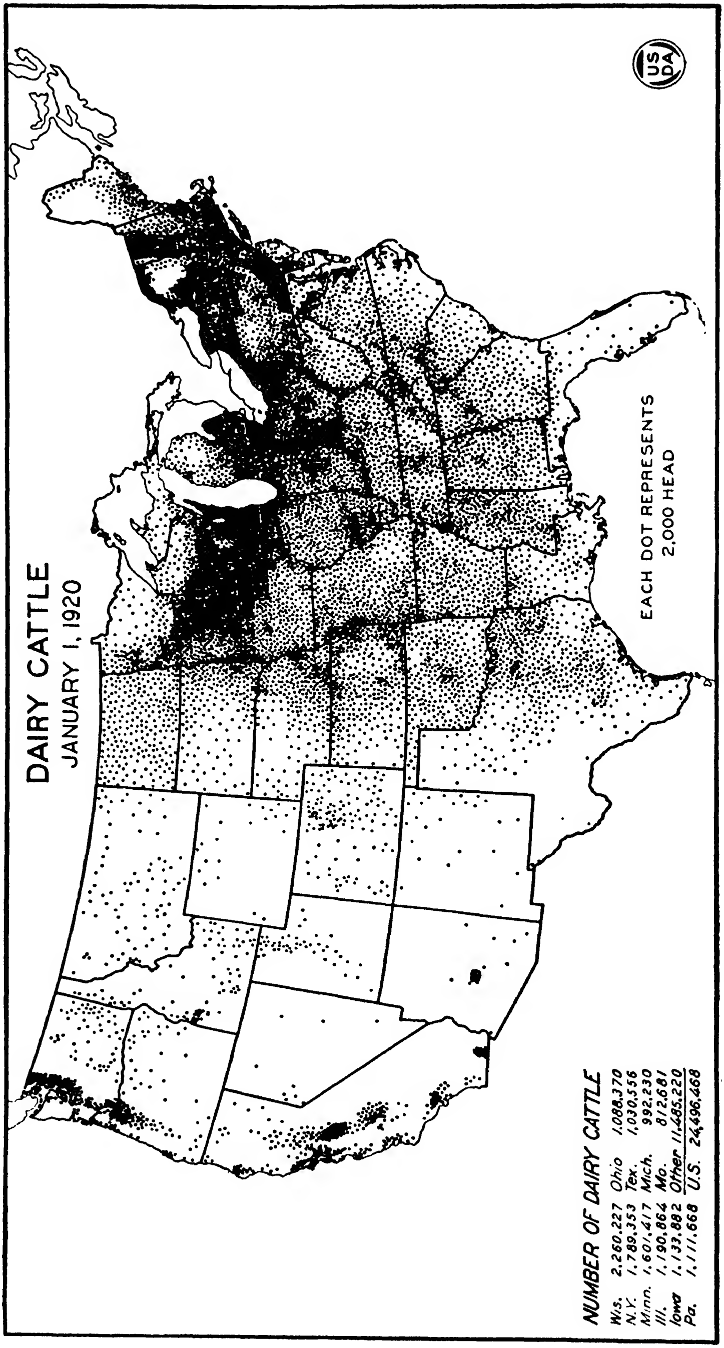

Fig. 114. Map courtesy United States Department of Agriculture.

The heavy dairy-cattle-producing area of the United States coincides usually with the areas of greatest density of populations.

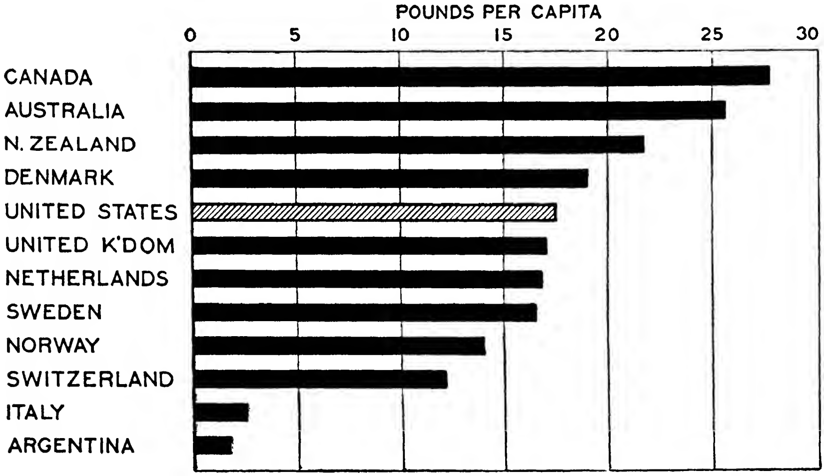

FIG. 115. Butter consumption in various countries. U.S.D.A. Yearbook, 1922.

Minnesota and Wisconsin are exceptions. Dairy cattle numbers are high in Minnesota, and high production is a result. Wisconsin

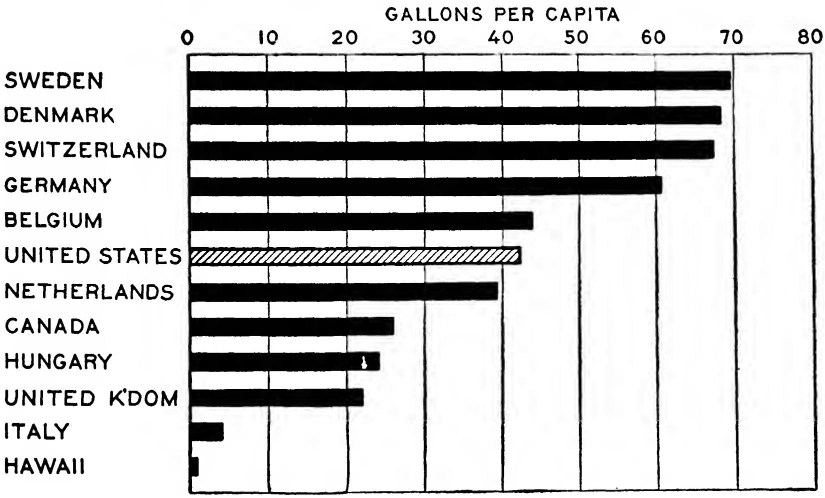

FIG. 116. Milk consumption in various countries. U.S.D.A. Yearbook, 1922.

ranks first in cheese production, supplying about 75 per cent of the nation's total. It ranks first in the production of evaporated milk, producing about one-third of the total. It ranks third in the production of creamery butter. In addition there are large quantities of

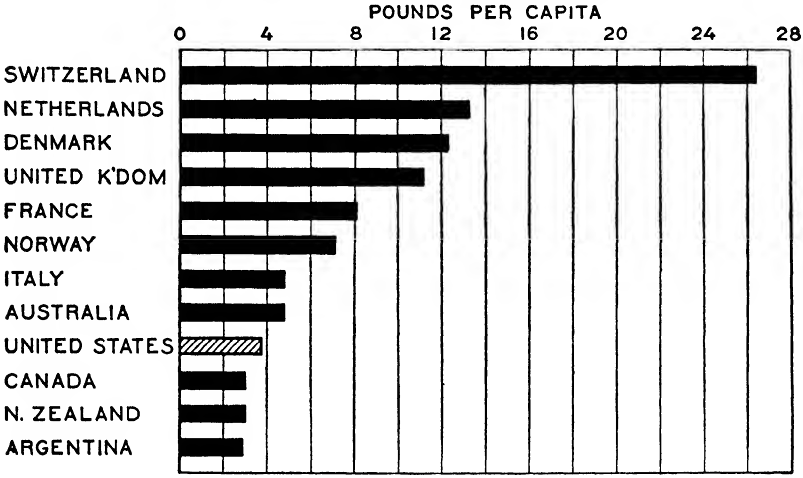

FIG. 117. Cheese consumption in various countries. U.S.D.A. Yearbook, 1922.

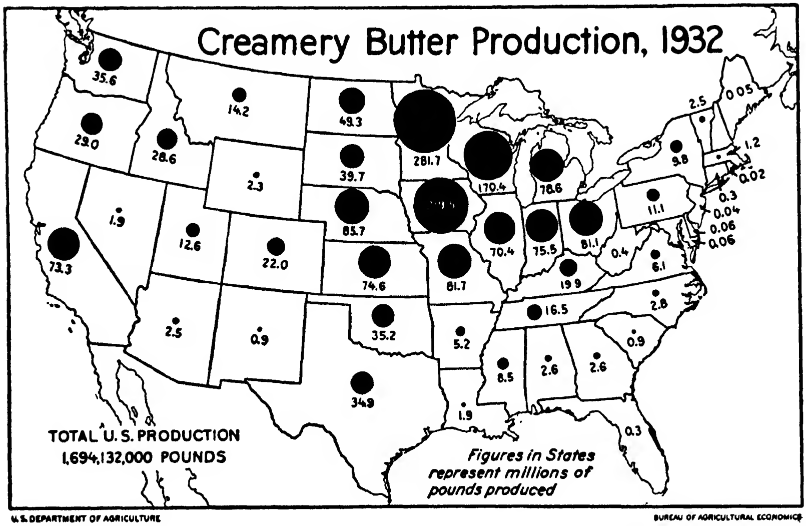

FIG. 118. Map from U.S.D.A. Bureau of Agricultural Economics.

market milk, bulk condensed milk, and ice-cream mix shipped from southern Wisconsin to Chicago. These facts help us to understand why Wisconsin leads all states in the number of dairy cows.

The three bar graphs showing the per capita consumption of butter, cheese, and milk are interesting because the United States holds fifth and sixth places. This is probably explainable on the basis of higher costs of meat in most European countries and their

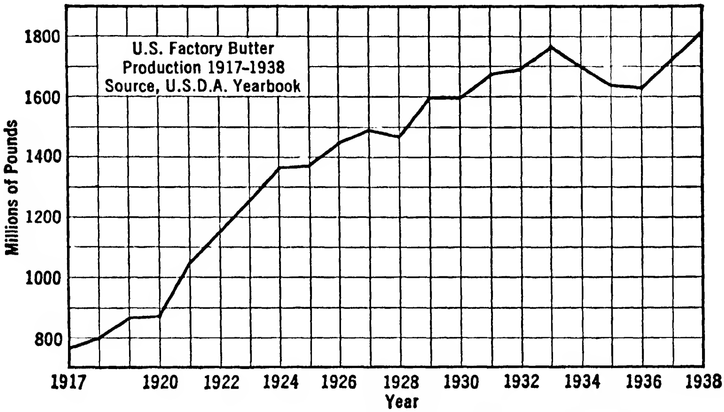

FIG. 119. Annual creamery-butter production, 1917-1938.

use of dairy products in place of meat. The recommendations of food authorities would greatly increase the use of dairy products in the United States. (See Chapter 3.)

The four graphs on the production of butter, cheese, ice cream,

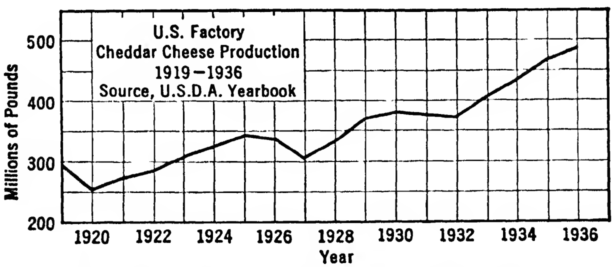

FIG. 120. Annual production of Cheddar cheese.

and powdered milk products show a very rapid increase in their production since 1910. The increase is greater than the corresponding increase in population for the same period. Education and greater interest in health and diet have played a large part. It is of interest to note the very remarkable decrease in ice-cream

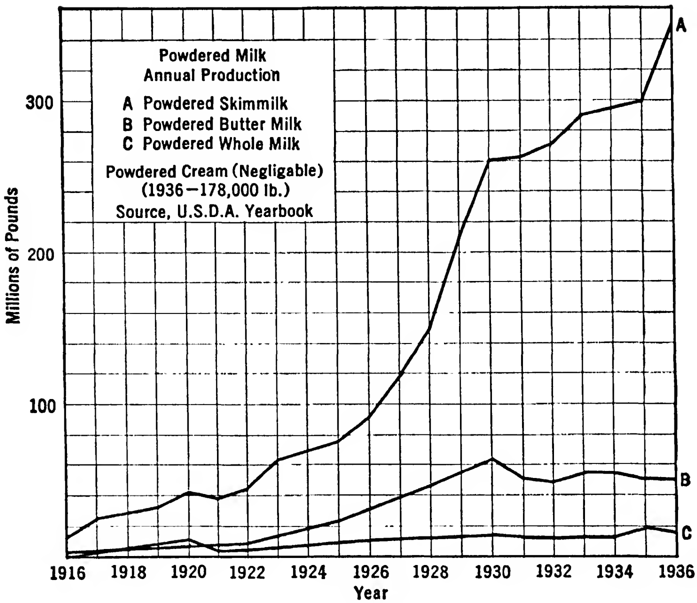

Fig. 121. Annual production of powdered-milk products, 1917-1936.

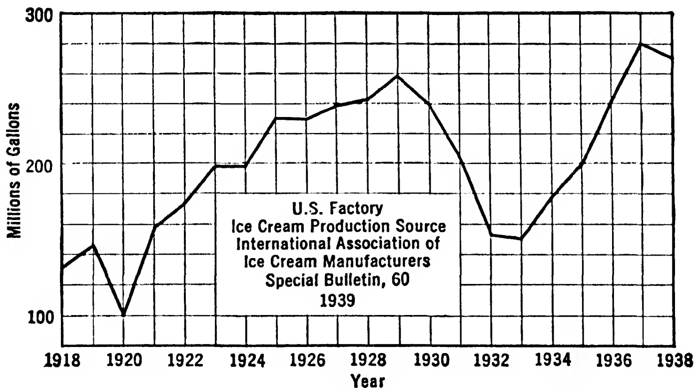

Fig. 122. Annual production of ice cream, 1920-1936.

production in the years 1933 and 1934. Ice cream is still considered a luxury product, or at least a product which may readily be dispensed with when strict budgeting is necessary.

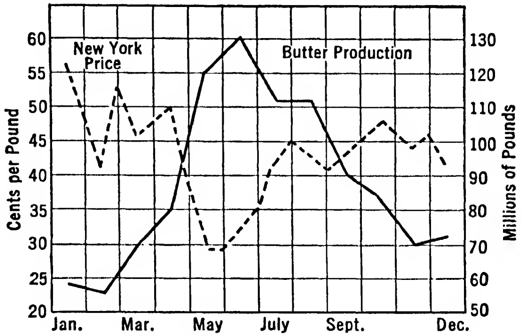

FIG. 123. Relation of butter production and butter prices, 1921. Such seasonal variations have decreased because of better quality of butter, better storage conditions, and the tendency to a more equalized production. See Fig. 86. U.S.D.A. Yearbook, 1922.

The relation of butter production and butter prices is represented in Fig. 123. Extremes of variation are undesirable. Production and consumption are disturbed.

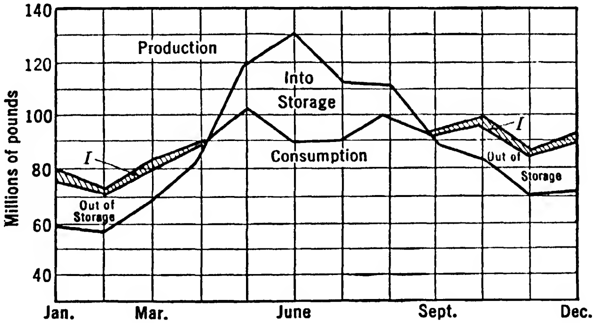

FIG. 124. Storage movement of butter. *I*—Excess of imports over exports. From U.S.D.A. Yearbook, 1922.

The storage of butter is desirable for two reasons: a better quality is required, extremes of price fluctuations are avoided.

Figure 125 has been prepared to facilitate a conception of the composition of the common dairy products. This information is used almost daily in dairy plants in testing and standardizing work.

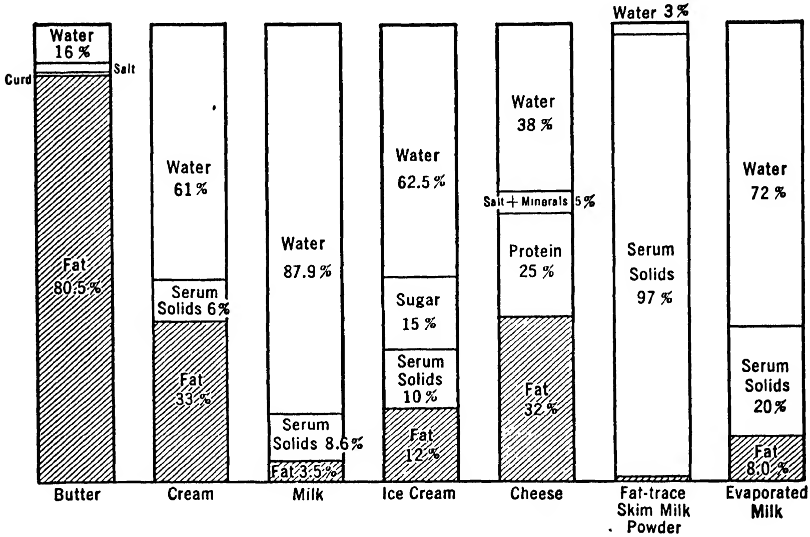

FIG. 125. Average composition of dairy products.

It is interesting to note that about 80 per cent of all milk produced is used as fluid milk or made into butter. We commonly think of cheese and ice cream as two of the major manufactured dairy products. This is a correct conception but it should be noted that only 6 or 7 per cent of the total milk supply is used for these products.

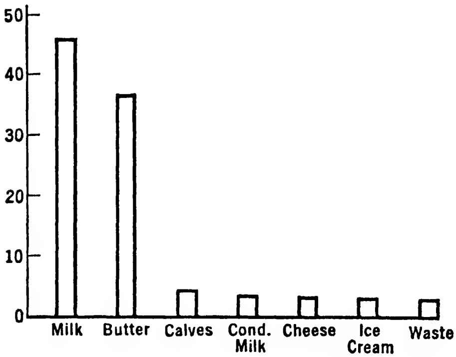

FIG. 126. Uses of milk. From U.S.D.A. Yearbook, 1922.

The production of oleomargarine is influenced by the price of butter and its quality, by the family pay roll, and by the number of unemployed. Other factors have some influence but are not primary. Probably one reason for the increase in oleomargarine production through the years is the

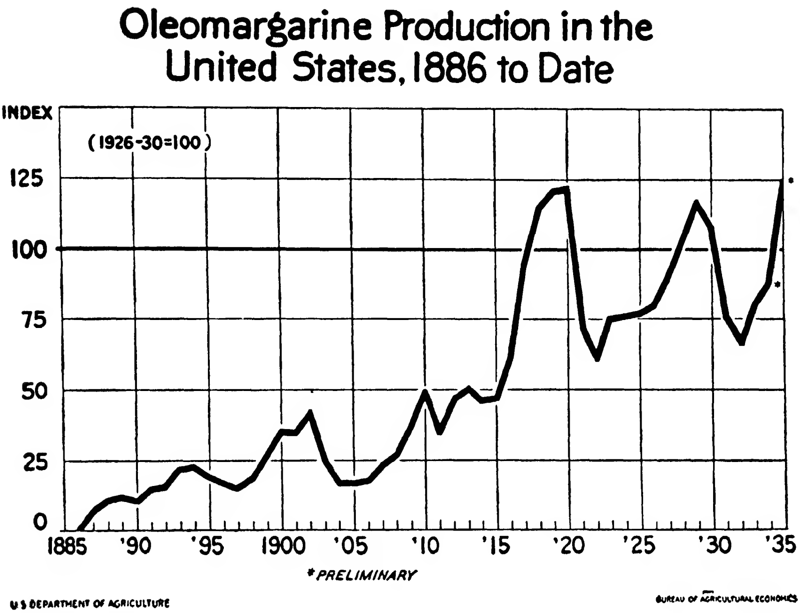

FIG. 127. Many factors influence the production of oleomargarine. Some of these are shown in a study of this series of graphs. See Figs. 128 and 129.

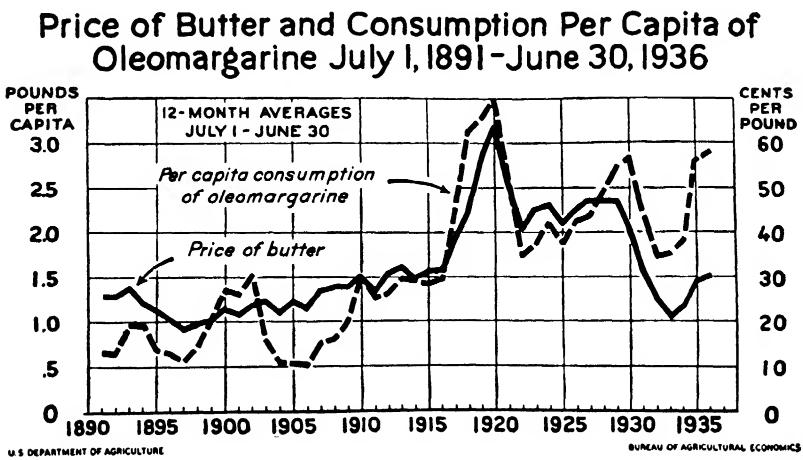

FIG. 128. The price of butter is an important factor in the production and use of oleomargarine.

gradual increase of city population. Oleomargarine production follows the price of butter quite closely. Cold storage of butter with

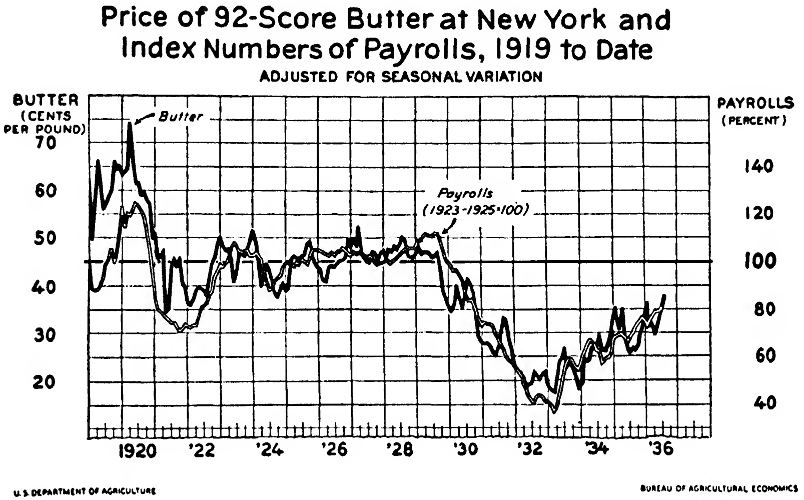

FIG. 129. There is a striking correlation between the price of butter and family income.

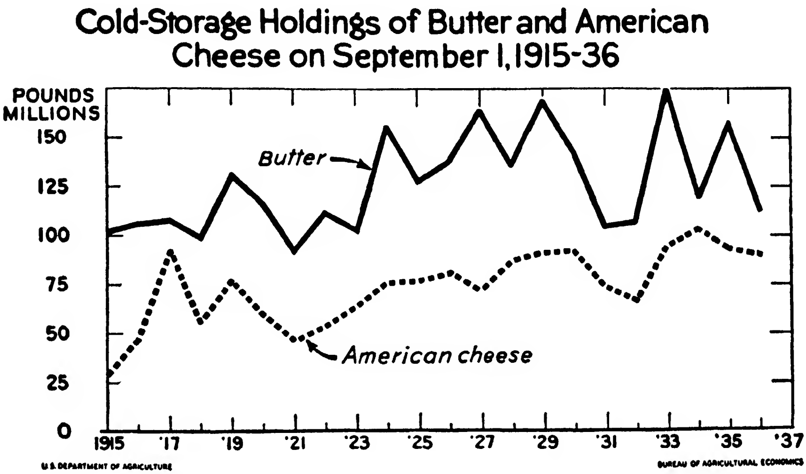

FIG. 130. There has been a general trend to increased storing of butter and cheese. This tends to reduce seasonal variations in price. (See Fig. 86.)

its price stabilizing effect will probably have increasing influence on oleomargarine production.

It is highly desirable that butter prices follow wages and family income. The price of most foods is similarly affected by the family budget. The farmer may be adversely affected by low butter prices because he has a rather fixed cost of production.

The cold-storage holdings of butter and cheese show an increase. This seems desirable from a socio-economic viewpoint. Improvement of refrigeration and storage facilities with some reduction in storage costs is probably an additional factor.

In the data which show the per capita consumption of dairy products it will be noted that cheese and evaporated milk show rather consistent increases. Data for 1937 show that 4.8 pounds of cheese were consumed. The use of milk, cream, and butter show very little change and no particular trends. This is important be-

PER CAPITA CONSUMPTION OF DAIRY PRODUCTS IN THE UNITED STATES

(Courtesy, U. S. D. A., Bureau Agricultural Economics)

Year	Evaporated Milk Pounds	Sweetened Condensed Milk *In Tins* Pounds	Milk and Cream Consumed as Such* (*Cities and Villages*) Gallons	All Butter *Creamery and Farm* Pounds	Cheese Pounds	Ice Cream Gallons	Margarine Pounds
1889	....	....	....	19.5	2.9	.....	.5
1899	....	....	....	19.9	3.7	.....	1.0
1909	....	....	....	18.0	3.85	1.04	1.0
1919	....	....	....	14.8	3.50	2.49	3.3
1920	6.5	....	....	14.7	3.50	2.46	3.5
1921	7.9	1.2	38.1	16.1	3.50	2.28	2.6
1922	8.4	1.7	....	16.5	3.70	2.43	1.7
1923	9.0	1.3	38.0	17.0	3.90	2.68	1.9
1924	9.8	1.2	38.6	17.38	4.20	2.50	2.1
1925	9.3	1.2	38.9	17.39	4.26	2.80	1.9
1926	9.8	1.1	39.3	17.76	4.36	2.77	2.1
1927	9.6	1.0	39.7	17.49	4.14	2.85	2.2
1928	10.4	0.9	39.8	17.12	4.11	2.90	2.5
1929	11.3	0.8	40.8	17.29	4.62	3.00	2.7
1930	11.4	0.8	40.7	17.30	4.71	2.82	2.8
1931	11.6	0.7	40.0	18.00	4.49	2.42	1.8
1932	12.5	0.5	40.0	18.14	4.39	1.79	1.6
1933	12.5	0.4	38.8	17.69	4.52	1.70	2.0

* The 1933 per capita consumption of milk and cream (consumed as such) by sections was: North Atlantic 42.9 gallons, South Atlantic 28.7, North Central 40.6, South Central 29.7, Western 40.1.

cause health authorities and the public schools encourage greater consumption. Figures 115, 116, and 117 show per capita consumption of some dairy products in foreign countries. Several countries show greater per capita consumption than the United States.

Estimated Per Capita Consumption in Different Countries

(From U. S. Government Reports—Agriculture or Commerce)

(From "Some Facts about Evaporated Milk and Other Dairy Products," Evaporated Milk Association, 1935)

Country	Whole Milk		Butter		Margarine		Cheese	
	Year	Gallons	Year	Pounds	Year	Pounds	Year	Pounds
1. United States	1933	38 8*	1933	17.69	1933	2.0	1933	4.52
2. Canada.....	1929	54.7	1930	30.3	1928	nil	1930	3.7
3. Great Britain	1922	25.0	1927	16 0	1928	13.3	1930	8.52
4. Germany....	1930	24.0	1929	16.5	1928	15.9	1928	10.6
5. France......	1931	29.5	1931	8.5	.....	......	1931	10 5
6. Switzerland..	1927	70.4	1930	13.4	.....	......	1930	16.1
7. Netherlands.	1929	42.7	1930	19.6	1927	17.9	1930	14.3
8. Denmark....	1927	22.0	1931	14.6	1927	45.2	1931	13.1
9. Sweden.....	1914	69.7	1928	16.5	1926	15.4	1929	10.2
10. Norway.....	1927	56.0	1927	9.6	1927	34.3	1929	10.8
11. Finland.....	1928	83.9	1931	6.35	....	......	1931	1.23†
12. Australia....	1926	37.1	1930	29.8	Negli	gible	1930	4.3
13. New Zealand	1927	37.4	1930	36.2	Negli	gible	1930	4.8

* In cities and villages. † Factory product only.

Notice the high butter consumption in Canada, Australia, and New Zealand. Notice also the butter consumption in Denmark and the large use of oleomargarine. From the standpoint of health this is not justifiable. A partial justification, however, appears in the fact that the Danes use large quantities of cheese. Only Switzerland and the Netherlands have higher per capita consumption. Finland consumes very large amounts of milk and relatively small amounts of butter and cheese.

Dairy products are exceeded only by livestock and livestock products as a source of income for the American farmer. If the states bordering on the Great Lakes are considered alone, the proportion of farm income from dairy products will undoubtedly exceed one-third of the total.

SOURCES OF FARM INCOME IN THE UNITED STATES

Includes Value of Products Consumed on the Farm

(Courtesy, U. S. D. A., Bureau Agricultural Economics)

Source of Income	1933	Per Cent in 1933	1932	1929	Average 1924-1930	Per Cent 1924-1930
Dairy products..	$1,250,000,000	20.4%	$1,260,000,000	$ 2,323,000,000	$ 1,857,000,000	16.4%
Livestock and products other than dairy and poultry.......	1,255,000,000	20.5	1,167,000,000	2,944,000,000	2,777,000,000	24.5
Fruits, nuts and vegetables....	1,188,000,000	19.4	936,000,000	1,838,000,000	1,740,000,000	15.3
Grains	600,000,000	9 8	322,000,000	1,283,000,000	1,426,000,000	12.6
Poultry and eggs	580,000,000	9.5	603,000,000	1,230,000,000	1,123,000,000	9.9
Cotton and cottonseed.......	670,000,000	11.1	431,000,000	1,389,000,000	1,398,000,000	12.3
Other crops.....	571,000,000	9.3	424,000,000	911,000,000	1,022,000,000	9.0
Totals	$6,114,000,000	100.0%	$5,143,000,000	$11,918,000,000	$11,343,000,000	100.0%

In addition to the above-mentioned sources of income, farmers in 1933 received $289,000,000 in rental and benefit payments, making a grand total of $6,403,000,000 in gross farm income.

BUTTER PRODUCTION IN VARIOUS COUNTRIES, 1929–1934

(International Yearbook of Agricultural Statistics)

Country	1929	1930	1931	1932	1933	1934
	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds
Germany.......	....	....	....	869,662	933,528	994,455
Belgium........	132,607	135,561	136,332	142,345	153,819	148,617
Denmark.......	394,623	418,874	429,897	414,465	407,851	402,560
Finland *.......	53,417	59,032	61,568	57,145	52,412	53,836
Latvia †........	34,477	42,053	44,159	44,251	36,645	36,408
Norway........	8,306	8,698	13,271	17,377	19,352	20,365
Netherlands....	190,272	191,460	186,197	187,863	194,198	199,505
Sweden.........	....	....	118,887	113,277	121,335	....
Switzerland.....	34,612	37,478	35,565	50,485	56,217	63,933
Canada.........	260,115	283,644	331,974	322,222	326,996	345,968
United States ‡..	1,598,248	1,597,747	1,667,452	1,694,132	1,762,688	1,694,708
Quatemala......	....	283	....	608	457	....
Argentina.......	61,474	74,005	80,312	81,293	71,852	64,674
Uruguay........	751	1,279	1,323	1,543	1,620	....
Japan..........	3,018	4,617	4,682	4,060	4,634	....
Australia.......	289,879	299,076	350,400	390,648	419,668	450,929
New Zealand....	224,511	258,304	262,306	277,663	333,170	362,654

* Produced in dairies. † Under control. ‡ Factory butter only, does not include farm butter.

CHAPTER 23

BENEFACTORS OF THE DAIRY INDUSTRY, DAIRY ASSOCIATIONS, AND DAIRY JOURNALS

The material of this chapter has as its general subject, education.

Of the many men who have contributed so much to the dairy industry, we select four and review briefly their lives and contributions. We are thankful that the life and work of one of these is in full flower: Dr. E. V. McCollum of Johns Hopkins University.

Some of the most active national dairy associations are listed. The educational efforts of these associations are noteworthy. Some have research committees which function throughout the year and report findings of benefit to the entire industry.

The part played by the dairy press is great indeed. Only an exceptional individual can work to the best advantage when compelled to develop all plans independently of all outside suggestions and influence. In fact, it is more likely that the successful man is he who has native ability and is reasonably resourceful, but who, in addition, keeps informed of latest methods and practices by the reading of good trade papers. A list of the journals covering various lines of the dairy manufacturing industry is given here together with their frequency of publication. They are all trade journals except the *Journal of Dairy Science*. Those engaged in the industry make excellent use of these journals. Most of them contain proceedings of conventions, abstracts of technical articles which have appeared in experiment station bulletins, progress reports of experimental work as well as market quotations, questions and answers, etc.

The *Journal of Dairy Science* contains material which is technical in nature. It is of greatest value to those who have had some scientific training. It contains detailed accounts of experimental work in experiment stations and in the laboratories of industrial concerns. Both dairy manufacturing and dairy production subjects are reported. A recently added valuable service of the *Journal* is that of abstracting literature. Abstractors throughout the United States and Canada report all worth-while literature with detailed references given. Some foreign literature is abstracted.

Stephen Moulton Babcock came to the University of Wisconsin in 1889 as experiment-station chemist. He had held a similar position at the New York Experiment Station at Geneva, N. Y. The dairy industry was making great strides in Wisconsin, and Professor William A. Henry, dean of the College of Agriculture, pointed out to Dr. Babcock the great need for a practical chemical test for fat in milk and cream.

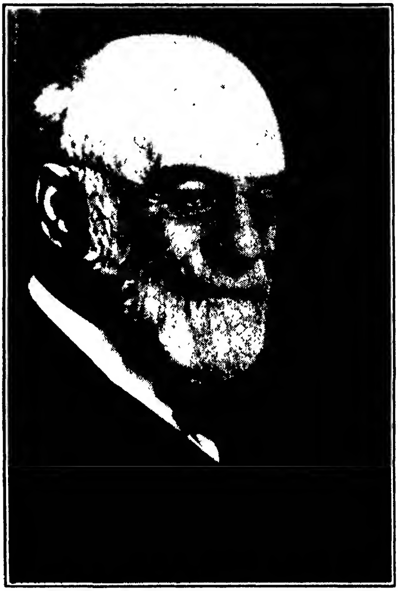

FIG. 131. Dr. Stephen Moulton Babcock. Experiment station chemist at Wisconsin University. Invented the Babcock test for milk fat in dairy products in 1890.

After much experimentation Dr. Babcock found a simple method which gave results that checked with complicated chemical tests. It worked for all the cows in the University herd except for Sylvia, a shorthorn cow. Dr. Babcock was urged to give the test to the industry regardless of this one individual case. His great thoroughness in all his work caused him to decide against this suggestion, and he continued research until the test produced results with all samples of milk.

Wisconsin Bulletin 24, published in July 1890, described the new Babcock test. It was entitled, "A New Method for the Estimation of Fat in Milk, Especially Adapted to Creameries and Cheese Factories." After recognition of its accuracy and practicability and its official acceptance, it has been universally used in the United States. Many foreign countries also use it very generally.

The question of taking out a patent arose. The patent rights were given to the world without benefit either to Dr. Babcock or to the University. Such magnanimity won great and lasting honors to the inventor. He was many times honored in the United States and many foreign countries as well. These honors were not immediately forthcoming, as it was some time before the test was officially adopted in the United States. As late as 1893, at the Columbian Exposition (World's Fair) in St. Louis, the Holstein breeders withdrew their cows from test because the Babcock test was to be used. It was shortly adopted, however, by all breed associations, by authorities in all states, and by the United States Department of Agriculture.

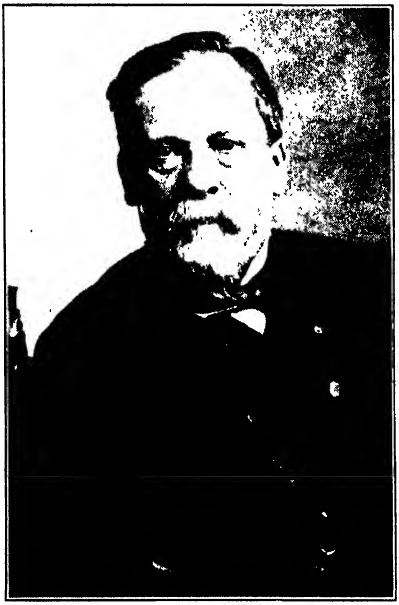

FIG. 132. Dr. Louis Pasteur. Eminent French scientist and bacteriologist. The process of pasteurization was named in his honor.

Dr. Babcock died July 1, 1931, at the age of 87. He was a tireless worker, a shy man, a faithful friend, and a willing consultant to all who sought his advice.

Louis Pasteur, a Frenchman, was born December 27, 1822, and died September 28, 1895. The modern practice of heating milk to arrest fermentation and souring traces back to Pasteur's studies on French wine and later on milk. In his honor, we call this heat treatment, pasteurization. French wines frequently fermented excessively and later soured, thus losing their fine aroma and flavor. Pasteur discovered that heating the wine at a certain stage of fermentation arrested further change and proper flavor and aroma were retained. This discovery was an invaluable service to the French grape and wine industries.

Later his studies on milk led to the same conclusion. Fermentation and souring were caused by bacteria. This was not in agreement with Dr. Liebig, the great German chemist, and Pasteur's discoveries were slow to be accepted. Repeated proofs were demanded. In 1878 he discovered the cause of puerperal or child-bed fever. In 1880 he discovered the cause of chicken cholera and, in 1881, the cause of hydrophobia. In 1877 he discovered the cause of anthrax and in 1881 provided a vaccine for treating this costly disease in livestock.

Visitors in Paris would do well to visit the grave of this great humanitarian and scientist who lies buried not far from the pretentious tomb of Napoleon. The great humanitarian and the great soldier. Let posterity decide who was the hero. Robert Ingersoll stood by Napoleon's tomb and reflected, "I thought of how many widows and orphans he had made."

Fig. 133. Dr. Carl Gustaf Patrik De Laval. Swedish technician and engineer. Inventor of the De Laval cream separator, the De Laval steam turbine engine, and other equipment of lesser importance.

Carl Gustaf Patrik De Laval was born in Sweden, May 9, 1845. He died in 1913. His great contribution to the dairy industry was the invention of the continuous cream separator in 1878. Probably his other major invention was the steam-turbine engine. Both these inventions bear his name.

The first hand seperators were imported into the United States in 1885 from the De Laval factory in Sweden. It should be noted here that the Babcock test for butterfat in milk and cream was invented about 1890, and so we see that these two major developments gave great impetus to the dairy industry at about the same time.

It has been estimated that the annual saving of butterfat in the United States represents $35,000,000 when centrifugal cream separators are used as compared with the old method of gravity cream rising.

The original De Laval Separator Company is located in Sweden. The De Laval Company in the United States might be considered a branch of the Swedish organization. Although this is true, nevertheless, the De Laval Company in the United States has grown far beyond the parent company. However, there is an annual conference of the two companies, either in Sweden or in the United States, and with mutual benefit.

De Laval received many honors. In 1879 he was given a medal by the Royal Agricultural Society of England. The King of Sweden presented him with the Cross of the Order of Wasa and made him a Knight of the Order of the North Star. In 1892 he was given a gold medal and made a member of the Academy of Science. In 1904 Germany honored him with a medal and membership in the German Engineers Society.

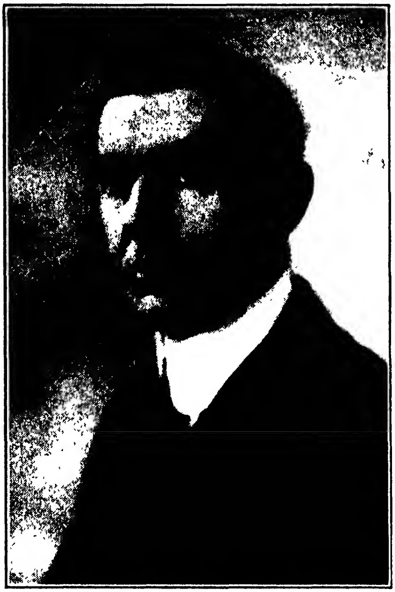

FIG. 134. Dr. Elmer Vernon McCollum. Internationally noted authority on vitamin and nutrition studies. (Member of staff at Johns Hopkins University.)

Elmer Vernon McCollum is in charge of research in nutrition at Johns Hopkins University in Baltimore, Maryland. He was born at Fort Scott, Kansas, on March 8, 1879. He received his doctor's degree at Yale, and in 1907 went to the University of Wisconsin. Here he initiated his famous studies of vitamins. He found that butterfat was superior to many other fats and oils in promoting growth. The growth-promoting factor was termed vitamin A. Later studies caused him to name dairy products, "Protective Foods."

His studies have given the dairy industry its deserved opportunity to advertise and encourage the use of more dairy products. He has performed an invaluable service to mankind.

In spite of his constant attention in conducting these extensive studies he has found time to appear before innumerable groups of societies and associations to present his findings. In addition, many publications are credited to him, chief of which may be said to be his text-book, "The Newer Knowledge of Nutrition." It is comprehensive and authoritative.

NOTE: Credit is due the Meredith Publishing Company of Des Moines, Iowa, for permission to use some of the facts here recorded. They are from "Ten Master Minds of Dairying," published in 1930.

Some of the more prominent dairy associations are listed below. Most of these are national in character although the activities and membership of some is restricted to certain sections because of the regional nature of the industry and the density of population. State associations are not listed because of lesser importance and great numbers. Names and addresses of officers of state and regional associations are readily obtained by inquiry at a local products plant.

DAIRY ASSOCIATIONS (1939)

National Creamery Buttermakers' Association
  A. W. Rudnick, Secy., Iowa State College, Ames, Iowa
American Butter Institute—formerly American Association of Creamery Butter Manufacturers
  N. W. Hepburn, Secy., 110 N. Franklin St., Chicago, Ill.
International Association of Milk Dealers
  R. E. Little, Secy., 309 W. Jackson Blvd., Chicago, Ill.
National Cheese Institute
  Geo. L. Mooney, Plymouth, Wis.
International Association of Ice Cream Manufacturers
  R. C. Hibben, Secy., Barr Bldg., Washington, D. C.
Evaporated Milk Association
  Dr. Frank E. Rice, Secy., 203 N. Wabash Ave., Chicago, Ill.
National Dairy Council
  111 N. Canal St., Chicago, Ill.
National Dairy Union
  A. M. Loomis, Secy., 630 Indiana Ave., Washington, D. C.
Dairy and Ice Cream Machinery and Supplies Association
  232 Madison Ave., New York, N. Y. (1939, renamed Dairy Industries Supply Assn.)
International Association of Dairy and Milk Inspectors
  Dr. Paul B. Brooks, Secy., State Health Dept., Albany, N. Y.

National Dairy Association
Chas. L. Hill, Pres., Madison, Wis.
American Dairy Science Association
Dr. T. S. Sutton, editor of *Journal of Dairy Science,* or Prof. R. B. Stoltz, secretary of the Association, Columbus, Ohio

For changes of address or names of officials of associations consult:

a. Dairy Industries Catalogue File (annual), by Olsen Publishing Co., 505 Cherry St., Milwaukee, Wis.
b. "Who's Who in the Butter, Cheese and Milk Industries," by *American Creamery and Poultry Produce Review,* Urner Barry Co., 173 Chambers St., New York, N. Y.

DAIRY JOURNALS

Journals covering subjects other than butter are listed below:

Ice Cream Review, 505 Cherry St., Milwaukee, Wis., monthly.
Milk Dealer, 505 Cherry st., Milwaukee, Wis., monthly.
Milk Plant Monthly, 327 S. La Salle St., Chicago, Ill., monthly.
Ice Cream Field, 461 Eighth Ave., New York, N. Y., monthly.
Ice Cream Trade Journal, 171 Madison Ave., New York, N. Y., monthly.
Dairy World, 608 S. Dearborn St., Chicago, Ill., monthly.

The Journal of Dairy Science is a technical journal, issued monthly by the American Dairy Science Association. It includes both dairy manufacturing and dairy production subjects. Subscriptions are $6.00 per year. Address the Science Press Printing Co., Lime and Green Streets, Lancaster, Pa., or R. B. Stoltz (see above).

Journals which are devoted to dairy manufacturing subjects *(including butter)* are:

The American Produce Review, formerly *American Creamery and Poultry Produce Review,* 173 Chambers St., New York, N. Y., weekly.
American Creamery Operator, Chaska, Minn., semi-monthly.
Creamery Journal, Waterloo, Iowa, monthly.

Dairy Produce, 110 N. Franklin St., Chicago, Ill., weekly.
Dairy Record, 391 Minnesota St., St. Paul, Minn., weekly.
Pacific Dairy Review, 500 Sansome St., San Francisco, Calif., monthly.
National Butter and Cheese Journal, 505 Cherry St., Milwaukee, Wis., monthly.
Southern Dairy Products Journal, Atlanta, Ga., monthly.
Canadian Dairy and Ice Cream Journal, Toronto, Canada.

APPENDIX A

We submit the following report of a survey made by the Olsen Publishing Company of Milwaukee, Wisconsin, and published in the *National Butter and Cheese Journal* for June 10, 1938. It is the most inclusive survey available at this time. To be authoritatively informed the reader must periodically call upon the proper state authorities for laws and regulations controlling the dairy industry.

A SURVEY OF CREAM GRADING LAWS IN THE UNITED STATES

That approximately half of the states in the United States have some form of cream grading laws is shown by a survey just completed by the *National Butter and Cheese Journal.*

A questionnaire sent out by the Journal brought replies from 40 of the 48 states. Of those replying, 50 per cent have cream grading laws; 8 per cent have some type of voluntary grading system; and 42 per cent had no grading laws whatsoever.

States indicating they have cream grading laws are:

Minnesota, Iowa, Illinois, Nebraska, North Dakota, Kansas, Oregon, Washington, California, Oklahoma, Connecticut, Missouri, New Mexico, Alabama, Idaho, Ohio, Tennessee, Colorado, Utah, and Mississippi.

States having no cream grading law are: Wisconsin, Massachusetts, Virginia, Montana, South Carolina, Indiana, New Jersey, Pennsylvania, Nevada, Maine, West Virginia, New Hampshire, New York, Wyoming, Michigan, Texas, and North Carolina.

Maryland, although having no grading law, defines number one and number two cream. Georgia defines grades of cream and in addition has inaugurated an "elimination" program to eliminate unfit cream. In Kentucky, under leadership of the state university, a voluntary system of buying cream on grade is in effect throughout most of the state.

Eight states did not reply to the questionnaire, hence no information is available as to whether or not they have cream grading laws or regulations. The states not replying are: Vermont, Rhode Island, Florida, Louisiana, Arkansas, South Dakota, Arizona, and Delaware.

Most of these states, it will be noted, are not generally considered butter producing states, hence it is reasonable to assume that most of them have no cream grading laws. Adding this number to those having no laws considerably lowers the percentage of those states having cream grading regulations.

COOPERATION GOOD

All of the states having cream grading laws report good to excellent support on the part of the industry. None of the law enforcing agencies complained of lack of cooperation on the part of either producers or butter manufacturers in their states. In several of the states, in fact, the laws were enacted at the insistence of the industry. In other states, passage of the law was prompted by excellent work being done by state cream improvement associations.

Several states report improved quality as a result of the cream grading law; others say results of the regulations are "good."

In most of the states, replies to the questionnaire show, the cream laws are enforced by the state departments. Some states, such as Oregon, have supervising graders. In others, as in Colorado, the law is enforced by the state department cooperating with the industry.

Of those reporting the dates on which their laws were enacted, 66 per cent pointed out that their laws had been put into effect since 1935; the remaining laws had been made previous to that time, some having been made as early as 1924 and 1925.

GRADES VARY

Grades established for cream vary in the various states. Of the states indicating a grade nomenclature, 53 per cent have two grades of cream, first and second grade. All cream not meeting requirements of these two grades is classed as unfit for human food and is rejected. Twenty-nine per cent of the states report three grades of cream: Sweet cream, grade one, and grade two. Six per cent of the states have three grades of cream: First, second, and third. Another six per cent have only two grades, sweet and sour. Still another six per cent report grade designations of A and B.

A few of the states commented on whether or not a differential is being paid on the various grades of cream. This differential is from one to three cents per pound of butterfat. In several states not having the price differential regulated by law, the industry voluntarily pays a differential.

States having three grades of cream: Sweet and number one and number two sour, are Minnesota, Iowa, North Dakota, Alabama, and Mississippi.

THE MINNESOTA LAW

The Minnesota law, passed by the 1935 legislature, defines the three grades as follows:

Sweet cream grade shall consist of fresh, clean, fine-flavored cream, the acidity of which calculated as lactic acid shall at no time have exceeded .20 per cent in cream;

Grade one shall consist of cream that is clean, free from undesirable odors and flavors, the acidity of which calculated as lactic acid shall at no time have exceeded .60 per cent at the time and place of purchase;

Grade two shall consist of cream that is too acid to grade as Grade One and/or contains undesirable odors and flavors in a moderate degree;

Unlawful cream shall consist of cream which contains dirt, filth, or other foreign matter which makes it unfit for human consumption.

The law further provides for coloring of illegal cream so it cannot be used for human consumption, and stipulates there shall be a "reasonable" price differential between grades, not to be less than one cent per pound of butterfat. Violations of the grading law are punishable by fines of not less than $25 nor more than $100.

CREAM GRADING IN IOWA

Definitions in the Iowa cream grading law are much the same as those in the Minnesota regulations. To "unlawful" cream, however, is added cream that is "stale, cheesy, rancid, putrid, decomposed, or actively foaming." Iowa also stipulates a price differential of not less than one cent per pound. Prices paid must be conspicuously posted. Every creamery or buying station must have a grader licensed by the state, the license being granted when the applicant has satisfactorily passed a state examination.

At least one sediment test must be taken of each patron's cream during each month, according to the Iowa law. If a patron's sample is unsatisfactory, additional tests must be taken until the patron has cleaned up his product. A harmless coloring material is put into unlawful cream to prevent its sale as food for human consumption. Failure to comply with the Iowa law brings the same penalties as in Minnesota.

John A. Feeney, chief of the Iowa Dairy and Food Division, in commenting on the law says:

"The attitude of the creamery industry is very favorable to this law. The quality of butter has been stepped up since the law went into effect. In most instances we have the cooperation of the producer, as well as the manufacturer."

NORTH DAKOTA LAW DIFFERENT

The North Dakota law, although having three grades similar to the Iowa and Minnesota laws, differs principally in its definition of grade one cream: "Grade one shall consist of cream that is clean, free from undesirable odors and flavors, and shall be of such quality that will make a butter scoring 90 or above." Definition of sweet cream grade, grade two, and unlawful cream are practically the same as the Iowa definitions of these grades. A minimum price differential of one cent is also established by the law. As in Iowa, each creamery or station must have a licensed grader. Penalty for violation of the law is a minimum fine of $25 and a maximum of $100.

"The attitude of creamerymen in the state," according to William J. Murphy, North Dakota Dairy Commissioner, "is very favorable to this grading law. The law was passed to meet the demand of two organized groups of creameries, namely, the Independent Creamerymen's Association and the Cooperative Creamerymen's Organization. There was some opposition to the law when referred to the legislature, but this opposition was mostly to the sweet cream grade. This law was put into effect July 1, 1937. It is enforced by the dairy department by inspections and check-ups by the fieldmen."

MISSISSIPPI STIPULATES FAT CONTENT

Mississippi's cream grading law is almost identical to that of Minnesota and Iowa, except that its sweet cream must have a butterfat content of not less than 20 per cent, and its first grade cream is to have a butterfat test of not less than 20 per cent nor more than 50 per cent. The sweet cream is to be classed as A-1. Each creamery and cream station must have a grader licensed by the state.

ALABAMA HAS THREE GRADES

The state of Alabama also has a cream grading law establishing three grades of cream—one sweet cream and two grades of sour. Sweet cream is defined as having an acidity which does not exceed .20 of one per cent calculated as lactic acid, and grade one sour cream "has at the time and place of purchase an acidity not exceeding .80 of one per cent. All grade one sour cream shall be delivered to the purchaser within four days, and shall be delivered to the butter manufacturing plant within 24 hours after purchased, unless suitable facilities are maintained for holding this cream at 50 degrees F. or below."

There is no differential in the law between grades of cream, but a voluntary differential of not less than three cents per pound was agreed to by the creamerymen. Most of the creamerymen signed the agreement which is not binding under the law, but is in written form and on file in the office of the Alabama Department of Agriculture and Industries.

The industry cooperates in its cream grading program very well, according to George H. Marsh, supervisor of the division of agricultural chemistry of the Alabama state department.

"There certainly was a demand for cream grading in this state," Mr. Marsh writes, "as the creamerymen, the cream station operators, the dairy educational forces of the state, including the experiment station and extension service, and the department of agriculture, were aware of the fact that there had to be something done to improve the quality of cream being sold in the state for the manufacture of butter. The cream grading law was put into effect March 1, 1937, and has been in effect for a little over a year. The law is enforced by the department of agriculture and industries and each place where cream is purchased has to maintain a licensed cream grader. He is licensed after he has shown his qualifications both by oral and written tests by an agent of this department. His license is subject to be revoked if he does not comply with requirements of the law."

Dairy products inspectors travel through the state to check-up on accuracy of cream grading.

CALIFORNIA DEFINITIONS

Although the state of California does not have compulsory cream grading, its agricultural code and regulations contain quality definitions of three grades of cream, the grade being based upon the quality of butter which the cream will produce. The three grades are designated as follows:

First grade cream is cream which lends itself readily to the manufacture of 92 score butter or above (first quality) being clean, smooth, free from undesirable flavors or odors, sweet or acid not to exceed .30 of one per cent and containing at least 30 per cent milk fat.

Second grade cream is cream which lends itself readily to the manufacture of butter scoring less than 92 but not less than 90 (second quality), being somewhat fermented, contains some undesirable flavor or odor, and contains more than .30 and less than .60 of one per cent acid.

Third grade cream is cream which lends itself to the manufacture of butter scoring less than 90 but more than 88 (third quality), may be slightly foamy or slightly curdy, has distinct off flavors, is old, and contains in excess of .60 of one per cent acid.

Cream unfit for human consumption is rejected.

"Practically all of the milk and cream produced for manufacturing purposes in California is regularly graded by representatives of this department in accordance with the provision of trust fund agreements between this department and manufacturers of dairy products," O. A. Ghiggoile, supervisor of dairy service of the California Department of Agriculture comments.

"This is strictly a voluntary program initiated by the dairy industry and financially supported by the industry. . .The payment of differentials in prices is not compulsory under our law, but in certain sections of our state the price differential is paid voluntarily by the plant operators."

Another state having three grades of cream is Oregon, which designates its grades as A grade, B grade, and C grade. A grade, in addition to being "clean to the taste and smell, smooth, without objectionable flavor or odor," must have an acidity content of not more than .50 of one per cent calculated as lactic acid, and must have not less than 28 per cent butterfat.

B grade must conform to the same regulations as A, except that it may have slightly objectionable flavor or odor, or is too sour or too old to grade as A. It may not have an acidity content, however, of more than .80 of one per cent.

C grade is cream meeting the requirements of B grade but it may have an acidity of more than .80 of one per cent acid and may have pronounced weed, feed, high acid or old flavor.

Unlawful cream is that which contains dirt, filth, oil, or other foreign matter—or that is stale, cheesy, rancid, putrid, decomposed, or actively foaming.

The grading law, according to A. W. Metzger, assistant chief of the division of foods and dairies of the Oregon Department of Agriculture, has been very successfully operating since put into force in May, 1937.

"This law," Mr. Metzger writes, "has been put into effect by the creamery industry, inasmuch as Oregon is an export state on butter it is necessary to ship only high score butter to the outside market, in order to obtain the present price for the producer.

"The present bulk of butter shipped from Oregon is 92 score, whereas a short time ago it was between 90 and 91 score. There is even a considerable amount of 93 score butter going into the outside market. So, I can truthfully say that the law was put into effect upon popular demand and is being received well throughout the state."

The Oregon law is supervised by 18 men who cover the state for the department, caring for other duties of the department as well as supervising cream grading.

STATES HAVING ONLY TWO GRADES

Most states (53 per cent) have only two grades of cream—first and second grade. Cream not coming under the definition of these two is classed as illegal and is condemned. States recognizing but two grades of cream are: Colorado, New Mexico, Kansas, Nebraska, Missouri, Illinois, Tennessee, and Oklahoma. A letter from North Carolina reveals that that state is contemplating a similar grading law.

The method of determining the various grades of cream varies in the individual states. Some of the states having but two grades specifically designate maximum acidity for first grade cream. Missouri, for example, has a maximum of .75 of one per cent acidity; Oklahoma sets the maximum at .40 of one per cent from October to March and .50 of one per cent acidity from April through September. Both Missouri and Oklahoma also set a minimum butterfat content of 25 per cent for grade 1 cream. Illinois, Nebraska, Kansas, New Mexico, Colorado, and Tennessee set no acidity standard for their first grade cream.

SEDIMENT TESTING IN NEBRASKA

In Nebraska and Tennessee, sediment testing is required in the grading of cream. Nebraska, for example, defines first grade cream as "good cream that is either sweet or sour, smooth, free from undesirable odors, clean to the taste, and practically free from sediment." Second grade cream is "cream that is too sour to grade as first or that contains undesirable flavors or odors in a moderate degree or that is slightly foamy, yeasty, stale, showing slight traces of sediment or too old to be first grade cream."

Pictures of sample sediment discs showing number one, number two, and unlawful cream sediment samples, are printed on large posters which have been distributed to all Nebraska creameries and cream stations.

A. L. Haecker, chief of the Nebraska Bureau of Dairies, Foods, and Drugs, reports that practically the whole state is on the cream grading basis and that the quality of the butter produced is actually showing an improvement.

With the exception of the sediment test phrase, the grades of cream are defined much the same in Illinois, Missouri, Kansas, Tennessee, and Colorado as they are in Nebraska, with the grading being done by the senses of taste, sight, and smell rather than by laboratory test.

SUCCESSFUL IN ILLINOIS

In discussing success of the grading program in Illinois, Marvin Eisner, assistant superintendent of the state department of agriculture, points out that

"As a whole, the creamery men in our state are highly pleased with the operation of this grading system. There are, however, a few that take advantage of the situation and purchase all cream on a number one basis. The establishment of these standards was inspired by the attitude of the federal government and the creamerymen of our state as represented by the Illinois Butter Improvement Association."

MISSOURI COOPERATING 100 PER CENT

In Missouri, the industry is behind the grading program "almost 100 per cent," John E. Clary, acting chief inspector of the state department of agriculture, reports. "At present," he writes, "the differential paid between number one and number two is pretty generally two cents, and agreed to by practically every creamery operating in the state."

KANSAS, NEW MEXICO POST PRICE

Both Kansas and New Mexico require that the prices being paid for cream be conspicuously posted in the creamery or cream buying station. In New Mexico, this posting of the price is the only way in which the paying of a differential between grades is enforced. A two cent difference has been established between first and second grade butter. This differential was established three years ago, and according to J. R. Poe, state dairy commissioner, the creameries have been cooperating 100 per cent. All number three cream is ordered to be condemned. Commissioner Poe reports that last summer he condemned over 200 cans of cream which he considered unfit for human consumption.

The Kansas law does not require that a differential be paid on the two grades of cream, but it does require that the price paid be posted.

"Our law," comments H. E. Dodge, state dairy commissioner of Kansas, "was passed in 1927 and was worked out in cooperation with the leading creamerymen doing business in the state. It is what you would call an agreed law, having the approbation of both the industry and the department. The enforcement agency is the dairy division of the state board of agriculture which is a non-political organization.

"The attitude of the industry has always been cordial and cooperative and during the past three years our department has carried on an extensive cream improvement campaign, cooperating with the Kansas Cream Quality Improvement Campaign, an organization of the creameries of the state maintaining a paid secretary to carry on the work. This organization, however, was recently discontinued because of the withdrawal of the support of a few of the creameries whose main offices are out of the state.

"We, however, expect to carry out our cream improvement program with such cooperation as we are able to obtain from local creameries and our state college."

GRADING VARIES IN COLORADO

Because of the geography of the state, establishment of a uniform cream grading system has been difficult in Colorado. "Because of the varied agricultural conditions in this state caused by our mountain and plains areas," writes State Dairy Commissioner W. H. Skitt, "we are forced to modify our grading in these different sections.

"In the cool mountain sections we are able to secure a better grade of cream, so can set our standard for first grade cream as one that will make 91 score butter or better. While on the plains we have to reduce the grade a point or a point and one-half, especially in the summer months before any differential is made in price. A deduction of two cents is made for second grade cream by agreement of the creameries but not enforced by this department.

"The industry has been hesitant about having a state law setting a price differential because of so many difficulties experienced in finding a method of properly establishing the grade. Until neighboring states as well as ourselves agree on cream grades, a state law is possibly out of the question as far as paying a difference in price is concerned."

IDAHO DEFINES "SWEET AND SOUR"

The state of Idaho has but two grades of cream: Sweet and sour. The law defines these two grades as follows: "Sweet cream . . . shall be cream having a clean flavor, not more than 0.2 per cent acidity, and not less than 25 per cent butterfat. Sour cream . . . shall be cream showing more than 0.2 per cent acidity or less than 25 per cent butterfat."

MARYLAND URGES GRADING

Although Maryland has no state law requiring the grading of cream, the state department of health urges all creameries to grade the cream as number one and number two to prevent the mixture of a good and inferior quality of cream. A. L. Sullivan, state food and drug commissioner says that all creameries pay more for grade A and that most of them are anxious to grade the cream. The following types of cream are classed as number two:

1. Cream which may be high in acid without evidence of decomposition; 2. steamings; 3. garlicy cream or cream containing plant odors; 4. slightly yeasty; 5. cream containing a small amount of foreign matter.

UTAH DEFINES CREAM

In Utah the state law provides only the definition of cream and gives the State Board of Agriculture power to establish grades on dairy products, which would include cream. At present no such grades have been established, but Guy P. Stevens, chief inspector of the dairy and food division points out that his department has formulated grades for cream and manufacturing milk to be used in a three-month survey during the current season. He says that the department hopes to obtain information through this program which may be used in the establishment of grades.

GEORGIA'S "ELIMINATION" PROGRAM

Georgia has no cream grading law, but it does have an "elimination" program. This elimination program, started last year, is explained by J. L. Bailey, Jr., of the dairy division of the Georgia Department of Agriculture as follows:

"Instead of a grading program," Mr. Bailey writes, "we have made an effort to eliminate the unfit cream for use. This cream is defined in this manner: 1. All cream containing filth to a degree to which a discriminating and unbiased person would object; 2. All cream containing mould on the surface or having a cheesy odor in any degree indicating the presence of mould; 3. All cream having a 'ratty' flavor; 4. All cans of cream sufficiently yeasty to be in an active state of fermentation so that the cream overruns the container or has a decided carbonic or carbonated odor; 5. All cream that has a definite kerosene, gasoline, or oily odor; 6. All cream having a vomitous odor; 7. All cream that is, without question, putrid, rancid, or otherwise similarly decomposed or objectionable."

The state has also issued an order that the producers use only standard milk containers to store and deliver their cream rather than any vessel that would hold cream.

"We do not feel that this program has had any tendency to discourage the production of cream," Mr. Bailey comments, "and at the same time the quality of butter offered for sale in the state has been greatly improved. There is no number three cream sold or graded in the state." Several Georgia creameries are paying for the cream they purchase on a grade basis.

KENTUCKY'S VOLUNTARY GRADING

Kentucky has no state cream grading law, but Sarah V. Dugan, director of the Bureau of Foods, Drugs and Hotels in that state announces that there is a voluntary system of buying cream on grade through a large portion of the state under leadership of University of Kentucky.

LICENSE GRADERS IN WASHINGTON

In the state of Washington, the grading law also provides for the licensing of graders. Regularly employed state inspectors assist and supervise the licensed graders in performing their work. "Due to the fact that the graders are licensed, and their licenses revokable, comments M. R. Hales, supervisor of dairy and livestock with the Washington Department of Agriculture, "we use this weapon as a means of enforcing our grading regulations, and if a grader fails to perform his work satisfactorily, his license is revoked."

Although no price differential is set by law, some of the creameries in the state are paying a premium for number one cream.

In a number of states not having cream grading laws, some of the cream buyers voluntarily buy on a grade basis. Some of these states are Wisconsin, Virginia, Montana, Indiana, Nevada, West Virginia, Texas, and Michigan.

WHY WYOMING HAS NO LAW

Some of the reasons given why certain states do not have grading laws are interesting. The set-up in Wyoming, for example, is explained by Arling Gardner, acting commissioner of agriculture:

"Wyoming has been actively interested in the national cream improvement program since it was instituted several years ago. Due to the fact, however, that Wyoming is an exporting and not an importing cream state, it is impossible for the dairy industry of Wyoming, in cooperation with this department, to push cream improvement any harder than this program is being enforced in our surrounding states. If this were not the case, all our cream would leave Wyoming.

"At the present time, we feel that butter grading has more merit than cream grading, therefore we are demanding that all butter grading less than 89 be definitely labelled 'Under Quality Butter.' This plan automatically forces the proper grading of cream by the creameries. We also have control over the quality of butter shipped into Wyoming under this arrangement."

WISCONSIN HAS NO GRADING LAW

Harry Klueter, chief chemist of the Wisconsin Department of Agriculture and Markets, discusses that state's lack of a cream grading law in this manner:

"We have always felt that if we could get public sentiment to back us and the industry to cooperate with us to such an extent that we could obtain absolute compliance with section 97.36 and 97.37 of the Wisconsin statutes, the milk and cream delivered at plants in Wisconsin would be of such quality that if the plants and equipment where it is manufactured into a finished product, and the workmanship is right, we would be able to have all the butter of the quality that would score 93 or better and the cheese of such quality as would deserve a state brand when properly cured.

"We likewise feel that that unless we do have the cooperation of the industry or plant operators as well as public sentiment back of it, cream grading will not be of much consequence even after it has been established."

MICHIGAN REGULATES STATIONS

Although the state of Michigan has no grading law, it recently enacted regulations which govern cream station requirements.

WEST VIRGINIA TO GRADE

That buying of cream on grade will be established in West Virginia within the next few years is the opinion of James E. Weber, dairy specialist, West Virginia Department of Agriculture, who points out that the state has been working vigorously on a cream improvement program for several years, and that very noticeable results have been obtained.

NORTH CAROLINA PLANS GRADING

North Carolina is considering establishment of a cream grading system, according to C. W. Pegram, chief of the dairy division of the state department of agriculture.

"In fact," he writes, "the writer plans to set up a voluntary grading plan with interested plants at a very early date . . . Tentatively, our grades would be Numbers one, two, and three. Number three would be rejected. The tentative differential price would be two cents between grades one and two.

"We have many problems in connection with cream grading, such as small deliveries of cream per patron and lack of cow population per mile. Grading seems to be not only helpful in making improvement of our creamery butter, which is necessary if we are to compete with butter from other states and butter substitutes."

STRESSES NEED FOR GRADES

In the state of Virginia, a voluntary grading plan was discontinued several years ago. Since its discontinuance, the state dairy and food division has seized and destroyed "quite a lot of cream." Under the voluntary plan, three grades were established, with number one bringing a premium of five cents per pound over number two, and number two carrying a differential of five cents over number three. Hence, there was a spread of 10 cents between grades one and three.

"Personally," states S. S. Smith, director of the dairy and food division, "I do not believe that we can ever expect to accomplish very much in cream improvement unless we have a substantial differential in price between the grades of cream, which is backed up by law or regulations compelling adherence to the program outlined for this purpose!"

APPENDIX B

CHICAGO MERCANTILE EXCHANGE

BUTTER CLASSIFICATION AND GRADES *

700. BUTTER CLASSIFICATION.—Butter shall be classified as "Creamery," "Ladles," "Renovated," "Packing Stock," and "Grease Butter," and shall be designated as "Fresh," "Short Held," or "Storage."

701. CREAMERY BUTTER—Creamery butter shall be butter made from cream in a creamery, and may be salted or unsalted.

702. CENTRALIZED CREAMERY.—Centralized Creamery butter must be made in a creamery from cream brought to the creamery either by railroad, express or other means from individual shippers or cream stations.

703. LADLES.—Ladles shall be butter which is collected in rolls, lumps, or whole packages and re-worked or re-churned, re-salted or re-colored by the dealer or shipper.

704. RENOVATED.—Renovated butter shall be produced by melting the butter, clarifying the fat therefrom and re-churning with fresh milk, cream, skimmed milk or other similar processes.

705. PACKING STOCK.—Packing stock butter shall be butter from a creamery or dairy, without added moisture or salt, which has been collected in any quantity and packed in tubs, barrels, or other containers. It must be fit for human consumption and free from adulteration.

706. GREASE BUTTER.—This classification shall include all grades of butter below thirds. If "packing stock" the grade shall be below number three. In all cases it shall be free from adulteration.

707. MOULDY BUTTER—NO GRADE.—If butter is found to be mouldy, on either the inside of the package or the parchment liners show mould specks, indicating mould development, the butter shall not be entitled to receive a grade. If the mould development is not too pronounced, the butter may be reconditioned and eligible for another inspection.

708. BUTTER CONTAINER.—All butter offered on Change, except as otherwise provided in this rule, must be packed in new standard white ash or western spruce tubs of approximately 64 pounds capacity, with wood or standard metal hoops. Containers must be paraffined or lined with parchment paper.

* Taken from Rules Book, p. 70, April, 1937. (Courtesy of the Exchange.)

Butter may be offered on the spot call in other types of package if it is so specified at the time it is offered. Packing stock may be in miscellaneous packages.

709. BUTTER GRADES.—Creamery butter shall be graded as Extras, Extra Firsts, Standards, First, Seconds or Thirds, and shall be salted unless specified as unsalted.

Renovated butter and Ladles shall be graded as No. 1 or No. 2, Packing Stock as No. 1, No. 2, or No. 3.

710. SCORING.—For the purpose of assisting in determining the grade the following official schedule shall be used for scoring:

Salted Butter		Unsalted Creamery Butter	
Flavor	45 points	Flavor	45 points
Body	25 points	Body	30 points
Color	15 points	Color	15 points
Salt	10 points	Style	10 points
Style	5 points		

711. CREAMERY EXTRAS.—Extras shall consist of the best grade of butter in the season when produced and must score 92 points or better. Flavor must be fresh, sweet, and clean when offered as "fresh" or "short held," and must be sweet and clean when offered as "storage." Body must be firm and of good texture. Color must be no lighter than "A" and no higher than "D" as shown on the Nafis Standard Butter Color Rod, but must be uniform and neither streaked nor mottled. Salt may be defined as light or medium, but must not be gritty. Containers must be sound, uniform and clean.

712. CREAMERY EXTRA FIRSTS.—Extra Firsts shall be a grade of butter just below Extras, scoring from 90 to 91½ points inclusive. Flavor must be sweet; must be fresh and clean, just below the requirements demanded of Extras when offered as "fresh" or "short held," and comparatively sweet and clean when offered as "storage." Body must be firm and of good texture. Color must be no lighter than "A" and no higher than "D" as shown on the Nafis Standard Butter Color Rod, but must be uniform, neither streaked nor mottled. Salt may be light or medium but must not be gritty. Containers must be sound, uniform and clean.

713. CREAMERY STANDARDS.—Standards shall be a grade of creamery in carlots of one creamery's make, scoring less than 90 points. Flavor must be fresh and clean, if offered as "fresh" or "short held" and clean if "storage." Body must be firm and of good texture. Color must be no lighter than "A" and no higher than "D" as shown on the Nafis Standard Butter Color Rod, but must be uniform, neither streaked nor mottled. Salt may be light or medium but must not be gritty. Containers must be sound, uniform and clean.

714. CREAMERY FIRSTS.—Firsts shall be a grade of butter below Extra Firsts, scoring 88 to 89½ points inclusive. Flavor must be reasonably sweet. It must be reasonably clean and fresh if offered as "fresh" or "short held," and reasonably clean and reasonably sweet if "storage." Body must be reasonably firm and of fairly good texture. Color reasonably uniform. Salt may be light, medium or high. Containers must be sound, uniform and clean.

715. CREAMERY SECONDS.—Seconds shall be butter of a grade below "firsts," scoring from 84 to 87½ inclusive. Flavor must not show onions, garlic or similar flavors. Color must be fairly uniform, but may be mottled. Salt may be light, medium, or high. Containers must be sound and uniform.

716. CREAMERY THIRDS.—Thirds shall be a grade below "Seconds," and may consist of promiscuous lots, scoring from 79 to 83½ inclusive. It may be off-flavored and strong on tops and sides, more or less rancid. Body not required to draw a full trier. Color may be irregular or mottled. Salt high, light or irregular. Containers, any kind mentioned at time of sale.

717. UNSALTED CREAMERY EXTRAS.—Shall consist of the best grade of butter in the season when produced and must score 92 points or better. Flavor must be fresh, sweet and clean when offered as "fresh" or "short held," and must be sweet and clean when offered as "storage." Body must be firm and of good texture. Must be free from artificial color and salt. Containers must be sound, uniform and clean.

718. UNSALTED CREAMERY EXTRA FIRSTS.—Shall be a grade of butter just below Extras, scoring 90 to 91½ inclusive. Flavor must be sweet; must be fresh and clean, just below the requirements demanded of Extras when offered as "fresh" or "short held," and comparatively sweet and clean when offered as "storage." Body must be firm and of good texture. Must be free from artificial color and salt. Containers must be sound, uniform and clean.

719. UNSALTED STANDARDS.—Shall be a grade of Creamery in carlots of one creamery's make scoring not less than 90 points. Flavor must be fresh and clean if offered as "fresh" or "short held," and clean if "storage." Body must be firm and of good texture. Must be free from artificial color and salt. Containers must be sound, uniform and clean.

720. UNSALTED CREAMERY FIRSTS.—Shall be a grade of butter below Extra Firsts, scoring 88 to 89½ points inclusive. Flavor must be reasonably sweet. It must be reasonably clean and fresh if offered as "fresh" or "short held," and reasonably clean and reasonably sweet if "storage." Body must be firm and of fairly good texture. Color reasonably uniform. Must be free from salt. Containers must be sound and uniform.

721. UNSALTED CREAMERY SECONDS.—Shall be butter of a grade below Firsts, scoring from 84 to 87½ inclusive. Flavor must not show onions, garlic or similar flavor. Color must be fairly uniform, but may be mottled. Must be free from salt. Containers must be sound and uniform.

722. UNSALTED CREAMERY THIRDS.—Shall be a grade below Seconds and may consist of promiscuous lots, scoring from 79 to 83½ inclusive. It may be off-flavored and strong on tops and sides, more or less rancid. Body not required to draw a full trier. Color may be irregular or mottled. Must be free from salt. Containers, any kind mentioned at time of sale.

723. No. 1 LADLES.—"No. 1 Ladle" must be uniform and solid boring practically free from lumps; color neither extremely light nor high and must be uniform. Flavor must be sweet and fresh. Salt must not be gritty. Package must be sound, uniform and clean.

724. No. 2 LADLES.—"No. 2 Ladle" must be reasonably uniform and solid boring. Color may be unsettled flavor reasonably sweet and reasonably fresh. Must not be loaded with salt but can be extremely light or high. Package must be sound, reasonably uniform and clean.

725. No. 1 PACKING STOCK.—No. 1 Packing Stock shall be butter as originally manufactured, without additional moisture or salt, solid boring, sweet and sound, free from mould; may be packed in barrels, tubs or boxes. When in either boxes or barrels same shall be packed full.

726. No. 2 PACKING STOCK.—No. 2 Packing Stock shall be original butter, 85% of it solid boring, the other 15% fairly solid boring, reasonably sweet and solid for the grade offered; must be free from mould; may be packed in different kinds of barrels, tierces, pails or boxes, with or without paper lining.

727. No. 3 PACKING STOCK.—No. 3 Packing Stock shall be a grade of butter just below No. 2 Packing Stock, but above the Classification of Grease butter. It may be packed in any or all kinds of packages.

Grades of Butter	Scores Required	
	Salted	Unsalted
Creamery extras	92	92
" extra firsts	90 to 91½	90 to 91½
" standards	90	90
" firsts	88 to 89½	88 to 89½
" seconds	84 to 87½	84 to 87½
" thirds	79 to 83½	79 to 83½

APPENDIX C

IOWA STATE TRADEMARK FOR BUTTER

Iowa has created and adopted a state trademark for butter manufactured within the state, "for the purpose of insuring a higher standard of excellence and quality, and to insure a more healthful product for consumption at home and abroad." Furthermore, it is the purpose of the law to promote educational work which will assist the Iowa buttermakers in producing the butter to be marketed under the state trademark and thereby secure a more uniform butter market and a higher market value for the butter manufactured in the state.

The mark as adopted consists of a heavy circle with an inner light circle, the center space being occupied by an outline of the map of Iowa. Within the outline appear in prominent letters the words, "Iowa Butter." In the space above the outline and within the light circle appear the words, "First Quality. License No. ——." The words "State Butter Control" are inserted in the space below the outline of the map and within the light circle.

These laws, quoted below, are found in Bulletin 51 issued in 1934 by the Iowa Department of Agriculture.

"3088. State Trademark for Butter. The state trademark for butter manufactured in this state shall consist of the words 'Iowa Butter' printed within an outline map of Iowa. Above said map shall be printed the word 'First Quality, License No. . . . .' and below, the words 'State Butter Control.' Said map and printed matter shall be circumscribed by a double circle, the outer circle being printed with a heavier line than the inner circle.

"Iowa Butter Control Board. There is hereby created the Iowa Butter Control Board composed of the President of the Iowa State Dairy Association, the President of the Iowa State Creamery Operators Association, the Dean of Agriculture of the Iowa State College of Agriculture and Mechanic Arts, the Head of the Department of the Dairy Industry of the same institution, and the Secretary of Agriculture, which board shall see that the requirements of the law are met on all butter manufactured in the State of Iowa for sale under the Iowa Butter Trademark and that the standards required by law are maintained by all creameries desiring to be classified and known as an Iowa Trademark Creamery, and the board shall make rules and regulations for the enforcement of this act.

"Iowa Trademark Creameries. Any creamery meeting the standards and requirements fixed by law shall be entitled to be classified and known as an 'Iowa Trademark Creamery' and no other creamery shall use said name.

"Requirements. Any creamery desiring to be classified and known as an 'Iowa Trademark Creamery' shall meet the requirements of the Sanitary and Dairy Laws of Iowa and must comply with the Iowa State and Federal standards as to butterfat and moisture contents.

"All butter sold under said trademark shall be manufactured from cream containing not more than two-tenths of one per cent acidity and shall have been pasteurized in accordance with the Pasteurization Laws of Iowa.

"All butter sold under the Iowa Trademark must score at least ninety-three (93) and be inspected at frequent intervals. All scoring and inspection is to be made by the Iowa Butter Control Board or its duly authorized representatives.

"Whenever a creamery qualifies as an Iowa Trademark Creamery the Board shall issue to said creamery a certificate to that effect, which certificate shall be subject to revocation by the Board for failure to maintain the standards and requirements fixed by law.

"Any creamery holding the classification of an 'Iowa Trademark Creamery' must become a member of the 'Iowa Trademark Butter Association,' which shall be a non-trading, non-profit sharing association of the creameries classified as Iowa Trademark Creameries and which association shall own and regulate the use of the Iowa Butter Trademark.

"The ownership of the Iowa Butter Trademark is hereby vested and lodged in the Iowa Trademark Butter Association and said association may own and hold said trademark for the benefit of its members. The Iowa Butter Control Board shall retain all supervision and control over the manufacture and sale of all butter sold under said trademark.

"The Iowa Butter Control Board shall hold regular semi-annual meetings at the Dairy Industry Building of the Iowa State College of Agriculture and Mechanic Arts in conjunction with the Executive Committee of the Iowa Trademark Association, which latter body shall act as an advisory body only at said meetings."

RULES AND REGULATIONS GOVERNING USE OF THE IOWA BUTTER TRADEMARK

"1. Butter sold under the trademark shall be manufactured in a creamery which meets the requirements of the Iowa Sanitary Law. Such creameries shall obtain a score of 85 or above, 100 being perfect, scored in accordance with the Iowa State Score Card for creameries.

"2. Requirements for maintaining a license for the use of the Iowa State Trademark will be as follows: No less than fifty per cent of the make during the year and no less than thirty per cent of the make during any one month during the year must be of State Brand quality.

"3. Butter sold under said mark shall be manufactured from cream, which has been pasteurized, either in the form of milk or cream. Pasteurization shall consist in heating the milk or the cream to a temperature of not less than 140° F. and holding above 140° F. for a period of not less than 20 minutes, or heating the milk or cream to a temperature of not less than 180° F. when flash heat is applied.

"4. If the butter is solid packed in tubs, the tubs shall bear the Iowa State mark on two opposite sides, the marks shall be placed immediately below the upper hoop or hoops, said mark to be three inches in diameter. In addition to the markings as stated, the top surface of the butter shall bear an imprint of the said mark, this imprint to be five inches in diameter and the imprint into the butter shall be from one-sixteenth to one-eighth of an inch in depth. Butter in boxes, either solid packed or in print, shall bear similar markings on both ends of the boxes as those placed on the outside of the tubs. A similar imprint shall be made into the butter if solid packed.

"5. Date of manufacture of butter shall be marked on the outside of the tub or box, close to the state mark, in letters not less than one-half inch in height, the same being placed in the following manner: 101 $_{23}$ 6. The figure '101' designates the number of the day of the year on which the churning was made. The figure '23' designates the number of the particular creamery and the figure '6' designates the number of the churning that day. Thus, for the above markings the reading would be that the butter was manufactured on the 101st day and was the product of sixth churning for that day.

"6. Parchments for print butter may be marked with the state trademark. The size of such marking shall be two inches in diameter.

"7. Application, in writing, shall be made to the Secretary of Agriculture, who will present the application to the Iowa Butter Control Board, which, after becoming satisfied that the applicant is qualified to comply with all requirements, will authorize the Iowa Trademark Butter Association to issue permit for the applicant to use the Iowa Trademark, and said Butter Association will furnish copies of the mark or marks and necessary equipment to the applicant.

"8. Any creamery obtaining permission to use the Iowa Trademark shall immediately, upon request from the Iowa Butter Control Board, submit samples of butter, for the purpose of scoring, to such places and in such quantities as may be designated, or submit to any system of quality control required by the Iowa Butter Control Board.

"9. All creameries permitted to use the Iowa State Trademark are required to enter in all scorings of the Iowa Educational contest and in all recognized national contests.

"10. The State Dairy Law makes it illegal for any person, firm, corporation, association or individual to use the said trademark for butter on their products without first complying with all the rules and regulations prescribed by the said Iowa Butter Control Board for the use of the same.

"11. Any person violating any of the provisions above shall be guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine of not less than twenty-five nor more than one hundred dollars or by imprisonment for not less than thirty days in the county jail. (Dairy laws of the State of Iowa, section 3047.)"

APPENDIX D

LEGAL REQUIREMENTS FOR BUTTER

(From The Creamery Journal, Feb. 1, 1932)

This is written for the purpose of setting forth, clearly, the legal requirements for making and marketing of butter, particularly in the north central states. It occasionally happens that a buttermaker is not sure just what present requirements are, and that he may be observing a moisture law, when in fact there is none in force. There is no intention here to encourage more than 16 per cent moisture, and it must be emphatically stated that a creamery operator must be sure he is observing all details in making fat and moisture tests if he is to go far above the 16 per cent limit. Scales must be accurate and samples carefully taken and prepared for testing.

From time to time there appear in the journals notices of seizures of shipments of butter and of prosecution by the federal government. These proceedings are now based on the 80 per cent butterfat requirement only. The federal authorities require a minimum of butterfat, and that butter shall not be adulterated.

In the Food and Drugs Act of June 30, 1906, butter is thus defined: Butter shall be understood to mean the food product usually known as butter, and which is made exclusively from milk and cream, or both, with or without common salt and with or without additional coloring matter and containing not less than 80 per cent by weight of milk fat, all tolerances having been allowed for.

This was approved March 4, 1923, and is enforced by the United States Department of Agriculture as an adjunct to the Food and Drugs Act. It applies only to interstate shipments of butter and not to intrastate shipments.

The standards in the north central states included in this survey all require 80 per cent of milk fat but do not limit the moisture to 16 per cent except in Minnesota and North Dakota.

Minnesota: 80 per cent fat and 16 per cent moisture. T. H. Arens, Ass't Dairy and Food Commissioner of Minnesota, in a statement dated

December 11, 1931, says that they have brought no prosecutions where butter contained over 16 per cent moisture and contained 80 per cent or more of milk fat. He further says that in reality they are only enforcing the 80 per cent fat standard, that he feels that the 80 per cent fat standard is sufficient and that the department's activities are confined to that regard only. He does make it emphatic, however, that the 24 per cent overrun law will be enforced. An attitude of toleration has given way to a more stringent policy, that creameries may cease to cut each other's throats.

Iowa: 80 per cent fat only. The Dairy and Food Division of Iowa prosecutes only in case of fat shortage, according to R. G. Clark, Chief of Dairy and Food Division, State Department of Agriculture. Mr. Clark has always believed that the 80 per cent fat requirement is sufficient. The real value of the law is to see that the consumer gets full food value for the milk, cream, and butter that he buys, and an excess of moisture of ½ to 1 per cent is not a serious matter if the butter contains the full 80 per cent of fat, an excess of moisture so small that it takes a chemical test to ascertain the fact.

Kansas: 80 per cent fat only—1927. The former 16 per cent moisture limit was discontinued in 1927, according to O. J. Gould, State Dairy Commissioner. There has been no legislation or move to establish legislation limiting overrun. The 80 per cent fat standard technically establishes a 25 per cent overrun. He does not believe that a hard and fast law of 16 per cent moisture is at all desirable or that the slight difference between 15½ and 17 per cent moisture or 2 per cent salt compared to 3½ per cent salt makes a vital difference to the consumer. No inspector should take advantage of a single case where the fat falls below 80 per cent in order to make a record of having prosecuted. Increasing moisture to the point where the fat falls below 80 per cent only comes about with lax methods of inspection.

Illinois: 80 per cent fat only, January 1930. Perry B. McCullough, in a letter dated December 19, 1931, states that 80 per cent fat only is required and that on January 14, 1930, the 16 per cent moisture standard was abandoned. He says, "This state has very little trouble with anyone offering butter for sale that contains less than 80 per cent fat and our commission felt that the moisture percentage was not of so much importance, hence the adoption of the new standard."

South Dakota: 80 per cent fat only. Mr. Julius Gerard explains that no prosecutions are made except on the basis of less than 80 per cent of milk fat, and the department goes no further in the administration of the law.

Wisconsin: 80 per cent fat only. A letter from Mr. Klueter, December 21, 1931, says, "Our state has never dealt with the matter of butter or adulterated butter on a moisture basis. We have always made the percentage of fat the determining factor. Personally I believe the 16 per cent moisture limit is desirable in the case of salted butter but with unsalted or lightly salted butter I see no reason why the moisture content should not be increased to compensate for lack of salt in order that one creamery may be on an equal competitive basis. We have under consideration the preparation and issuing of a uniform creamery statement making it compulsory to show the overrun each month. We are pretty well convinced that the single fat standard is the best sort of standard for butter."

The Wisconsin law reads, "Butter is . . . and contains not less than 82.5 per cent fat with a tolerance of 2.5 per cent, so that in no case shall the per cent of fat be less than 80."

North Dakota: 80 per cent fat—16 per cent moisture. C. S. Ladd, State Chemist, states, "It is our opinion that a higher standard of butter is produced than would be the case if only 80 per cent were required." Mr. Greenwood is also of the opinion the 16 per cent moisture limit is desirable.

For the benefit of dairy and food inspection may it be said that the utmost care must be exercised in the taking of samples. A report from a state chemist giving the percentage analysis may not in itself be evidence that the butter made by a creamery is of illegal composition. Too much emphasis cannot be placed on instructions to inspectors that is of vital importance to secure a fair and representative sample. Any slight carelessness here may result in the infliction of penalties where they are unwarranted. I further believe that samples for analysis should be taken at the factory and not from retail packages. This is equally applicable to ice cream and cheese. The identity of the sample is then certain.

The Kansas law regarding sampling is as follows: Five samples shall be taken from 5 different packages of any one manufacturer, or from any one tub or churning of butter and a careful analysis made by the official method of the Association of Agricultural Chemists.

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