A compendium of discussions relating to dairy technology and dairy manufacturing

by

G. H. Wilster
Professor of Dairy Manufacturing
Oregon State College
Corvallis, Oregon

AGRICULTURAL EXPERIMENT STATION
Oregon State College
Wm. A. Schoenfeld, Director
Corvallis
INDEX


5. Control of the Quality and Composition of Butter - Butter Manufacturers' Conference, University of Minnesota, September 1946.


7. The Vaccuration of Cream for Buttermaking - Butter Manufacturers' Conference, University of Minnesota, September 1946.


<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Conference Location</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.</td>
<td>Condensing Whole Milk for Ice Cream with the Vacreator - American Dairy Science Association, Guelph, Ontario, Canada, June 1947.</td>
<td></td>
<td>125</td>
</tr>
<tr>
<td>16.</td>
<td>The Reconstitutability of Dry Whole Milk - Western Division, American Dairy Science Association, Davis, California, September 1947.</td>
<td></td>
<td>130</td>
</tr>
<tr>
<td>23.</td>
<td>Factors in the Manufacture of Ice Cream of Excellent Quality - Annual Dairy Manufacturing Short Course and 37th Annual Convention, Oregon Dairy Manufacturers' Association, Oregon State College, Corvallis, Oregon, February 1948.</td>
<td></td>
<td>220</td>
</tr>
</tbody>
</table>
TECHNOLOGICAL DEVELOPMENTS IN THE BUTTER INDUSTRY

Marvelous developments in all branches of scientific activity have taken place during the past 50 years. There has been the adoption of new methods and processes in the established industries, and through inventions new industries of far-reaching importance have been established, giving employment to millions of people and contributing to the health, wealth, and general happiness of human beings.

A period of fifty years is a relatively short time. Yet, during this brief span we have seen the introduction in the butter industry of pasteurization, the combined churn and worker, the air tight separator, butter culture, automatic butter printers and wrappers, to mention a few of the outstanding developments, and scientists have shown that butter possesses natural nutritional properties necessary for our general welfare.

CHURNS

It is not many years ago since I received my first lesson in buttermaking. This was in a Danish creamery. The pasteurized sweet cream, ripened to a high acidity, was churned in a "Holstein" type of churn. This churn consisted of a straight-sided oak barrel having a smaller diameter at the top than at the bottom. The cream was added through the top opening. The barrel was stationary. Agitation was by means of a revolving paddle. The butter granules were lifted out of the churn by means of a hair sieve and were placed in a tub of water for washing. For working the butter, a revolving table "Mason Butter Worker" was used. When I, some time later, hired out as a butter maker in a large creamery in Queensland, Australia, we did not pasteurize the cream. Three box churns and a large Mason butter worker were used in the butter room.

In New Zealand the "Simplex" type of churn and butter worker has been common. A capacity of these churns (now of a combined type) of one hundred 56-pound boxes is not uncommon. For a number of years only minor changes in churn construction took place. The most radical change occurring in the United States, has been the elimination of the internal rolls. Instead of employing the principle of pressing the butter between rolls, with the roll-less type of churn the butter is worked into a homogeneous mass by pounding.

A definite disadvantage of the present-day churn is its wooden construction. Milk solids which lodge between the staves and in cracks are difficult to remove. Thorough washing and rinsing with water at near boiling point followed by drying are necessary. As sterilization of the churn is impossible, either with chemicals or with hot water, microorganisms are always present in these milk solids. There are records of a large number of churnings that have been spoiled, during
short time storage, by the activity of microorganisms that originated in the churn. Cheesy and even putrid flavors and moldiness are the most common defects in butter that result from contamination of churns.

The use of metal for churns has been contemplated by manufacturers for many years. The chief disadvantage of using metal for churns is that the butter is apt to adhere to the metal surface. By experimentation Mitchel, of Los Angeles, found that cast aluminum alloy, because of its porous rough surface, could be used satisfactorily as a material for churns. A considerable number of these all-metal cube shaped churns are being used in the west. Many millions of pounds of butter have been manufactured with this churn. One definite advantage of this type of churn is that all parts of the inner surface can be completely sterilized with hot water and steam.

Some western creameries have replaced the wooden butter packing utensils with utensils made from cast aluminum alloy. Aluminum butter tampers, paddles, and strikers are more sanitary than if they were made from wood.

Stainless steel butter moulds have been introduced. These are safer to use than wooden moulds as they can be easily cleaned and completely sterilized.

The metal churn constructed from stainless steel sandblasted on the inside was tested before the war in the Danish Experimental Creamery at Hillerod, Denmark. An innovation made was the mechanical removal of the butter from the churn. The finished butter was softened by spraying warm water on the outside of the churn while revolving. For summer-made butter the churn was revolved 10 revolutions per minute. Water at a temperature of 104° to 107° F. was used. By spraying the revolving churn for two minutes with warm water and continuing revolving for an additional five minutes the temperature of the butter was increased 3.2° F. A similar treatment also for two and five minutes resulted in an increase of 2.7° F., while a third similar treatment resulted in a further increase of 2.2° F. Thus, if the butter at the beginning was at a temperature of 61° F., the increase was 8 degrees, giving a final butter temperature of 69° F. This was followed by revolving the churn, without applying water to the outside, for an additional ten minutes.

For winter-made butter a slightly different procedure was followed. The churn room was maintained at a temperature of 61° to 64° F. Colder water was used so as to avoid melting the high-melting point glycerides as this would result in crumbly butter. The water temperature varied from 82.4° to 86° F. In three treatments the temperature of the butter was increased from 59° to 75° F. before it was in a satisfactory physical condition for removal. Pressure at about 3 to 5 pounds per square inch, using filtered air, was then applied to the interior of the churn. The butter could be forced out through a sanitary conductor.
to the butter firkin, standing on scales, by this means. It was re-
ported that this treatment of butter had no detrimental effect upon
the body and texture. This method of unloading churns has so far as
is known not been tried in the United States. (See 28th Report,
State Experimental Creamery, Hillerod, Denmark.)

\[\text{pH Value}\]

Research at several state experiment stations and in commercial
plants has definitely shown that butter which shows a low pH of the
serum keeps poorly, even in cold storage at zero degree Fahrenheit.
The most common and objectionable defect which develops is a fishy
flavor. Fishiness in salted butter can be controlled by keeping metal-
lic contamination to a minimum and by so regulating the acidity of the
cream at churning that the pH of the butter serum ranges from 6.6 to
7.0. Control laboratories can assist the buttermakers in their effort
to maintain a correct pH of the butter serum. Hussong in discussing
the significance of the measurement of the pH of butter stated that:
"The experience of three storage periods has confirmed the value of
using pH as a means of controlling keeping quality. This season the
pH of all butter scheduled for storage was determined and those churn-
ings falling outside the desired range were not stored. The results
of this procedure to date have been very satisfactory. In previous
years those churnings which developed a fishy flavor showed pH values
below the desired limit and confirmed observations made in the labora-
tory. The pH found to be most useful under the conditions studied was
7.0 ± 0.2 and it seems likely that the butter with pH values near the
top of the range possessed better keeping quality than that in the lower
range."

\[\text{YEAST AND MOLDS}\]

A few years ago it was demonstrated both in Canada and in the
United States that a high yeast and mold content of the butter general-
ly resulted when the cream was not pasteurized efficiently or when the
equipment used for transferring pasteurized cream and the churn and
butter packing utensils had not been properly cleaned and sanitized.
With a high yeast and mold count would be associated a high bacterial
count. As a result of this work recommendations for properly pasteur-
izing cream and for cleaning and sterilizing pumps, pipes, strainers,
valves, churns, moulds, etc., have been published. By following these
directions it is possible for efficient buttermakers to make butter
which regularly has a low yeast and mold count, provided, of course,
that the equipment is in a satisfactory physical condition.

\[\text{PARCHMENT WRAPS}\]

The proper preparation of parchment butter wraps is often over-
looked. When received from the manufacturer, either in rolls or in
reams, the paper is practically free from microorganisms. After it is
exposed to the air in the creamery or has become damp it may be a
source of bacteria, yeast, and molds. If used wet a good method of preparing wraps is to boil them in brine in a closed tank the evening before they are to be used. A metal tank, having steam coils in the bottom, with all parts constructed from stainless steel containing molybdenum is very satisfactory for this purpose. Treating parchment wraps with a solution of sodium propionate is also satisfactory.

PASTEURIZATION

The temperature used for pasteurizing cream for butter has been increased during the past 10 years. The higher temperatures have been found beneficial in improving the keeping property of the butter. Instead of using a temperature of 145°F to 150°F, as was common a number of years ago when pasteurizing in a vat, a temperature of 155°F to 160°F for neutralized cream and 160°F to 162°F for sweet cream is now commonly used in western creameries. With the flash method, instead of the former 180°F., a temperature of 190°F to 200°F is now used. In pasteurization of cream for butter the aim should be to destroy all enzymes and practically all microorganisms. All pathogenic organisms must be destroyed by any method of pasteurization. A scorched, or burnt, flavor should be avoided.

No method of pasteurization is a substitute for sanitation and proper care of milk and cream on the farm and in the creamery. By this process good quality butter cannot be made from poor quality cream. It is claimed that certain undesirable feed and weed flavors can be expelled by pasteurization. By the usual methods not much improvement is effected. Hunziker, a number of years ago, experimented with methods for the removal of undesirable feed and weed flavors. He found, that when treated in a vacuum some of the volatile substances responsible for the flavors could be removed. Equipment is now on the market exemplified by the Rogers high temperature pasteurizer, for removing objectionable feed and weed flavor.

VACREATION

In New Zealand there has been developed a combination vacuum process of pasteurization and removal of feed and weed flavor, as well as other loosely bound extraneous flavors, by steam distillation, known as vacreation. This method of pasteurization has been tested at the Oregon, Iowa, and Manitoba experiment stations. Favorable reports have been published. The pasteurizer used, known as a "Vacreator", is now being manufactured in the United States. In this process dry saturated steam is expanded as it continuously enters the vertical vacuum pasteurizing section and is thereby reduced in temperature to the desired pasteurizing point - usually between 195°F and 200°F. The steam being

* "Vacreator" is the registered trademark designating the Murray vacuum pasteurizers.
introduced at the top of the pasteurizer travels downwardly, and into it is rained the incoming cream to intermingle and travel its course with the steam. At the steam temperature the cream-steam mixture enters a second or steam distillation section where a higher vacuum reduces the temperature to between 160° and 180° F., and where volatile flavor compounds are distilled off. In the third or high vacuum section further temperature reduction and vapor removal occurs thus bringing the cream temperature down to between 100° and 110° F., and restoring the cream to its original consistency. The flow cycle is from about 8 to 10 seconds of time only. The method gives exceptionally high pasteurizing efficiency, produces clean natural flavor in cream, and greatly enhances keeping quality. Vacuumation of cream for butter seems also to have a bearing on the improvement of body and texture. There is very little butter being made in either New Zealand or Australia today that is not produced from vacuumed cream. About one hundred butter plants in Canada and the United States are now using this system of pasteurizing cream.

BUTTER TEXTURE

Crumbliness, stickiness and excessive hardness of fall and winter-made butter has been common, especially in sections where a large quantity of hay is fed to the cows. Buyers have complained that such butter cut badly when a mechanical butter cutter was used. Leakage of brine was excessive. Because of the hard and crumbly condition this type of butter did not enjoy favorable market acceptance when butter of a softer and waxier consistency was available. The problem was given attention by the Oregon Agricultural Experiment Station. In studies on the chemical and physical properties of the milk fat produced in the hay-feeding sections during fall and winter, it was found that the fat had a high melting point and contained a low percentage of the unsaturated and volatile fatty acids. Farm management practices did not permit a change in the feed in order to produce a lower melting point fat. It was necessary to develop a modified butter-making technique if butter of more desirable body and texture was to be made. During five years of experimentation one-third million pounds of butter in 383 churnings was made. A satisfactory method of manufacture, known as the "50-45-40" method was developed. In brief this is as follows:

1. The cream used must be in a good physical condition (not frozen, curdy, watery, etc.).
2. The fat content of the cream should be controlled to range from 32 to 38 percent.
3. The cream after pasteurization should be cooled to a temperature of 50° F.
4. The cream should be held overnight at a temperature of from 50° to 55° F.
5. Dilution of the cream with water must be reduced to a minimum.
(6) The temperature of the cream at the time of churning should be regulated so that the buttermilk can be drained within 40 to 50 minutes after churning is commenced.

(7) The butter granules should be the size of small peas.

(8) The butter granules should be washed and thoroughly chilled by means of cold water at a temperature not higher than 45°F.

(9) The buttermaker should adjust the amount of water added with the salt so that the butter when not completely worked will contain within 1 percent of the desired moisture.

(10) The final working after the make-up water is added should be so thorough that leakiness is not observed on the surface of the printed butter.

(11) The churn and butter worker must be in such condition that the butter does not stick to them.

(12) The churning, working, and packing operations must be done with dispatch.

(13) The freshly packed moulds or cubes of butter should be placed in a refrigerator maintained at a temperature of 40°F.

(14) The whole process of buttermaking must be done as directed with no deviation.

If the full benefit of this method is to be obtained there must be no short cuts. Expert workmanship on the part of the buttermaker is essential.

This method of butter manufacture is now used by a large number of western creameries and is being recommended by several large butter distributors in California, Washington, and Oregon.

**FAT LOSS**

Dairy technologists have given much attention to the control of the amount of fat lost during butter manufacture. Many creamery managers have not been aware of the importance of properly controlling this. Before research on this problem was started at the Oregon Agricultural Experiment Station a survey showed that in a large creamery, using the vat method of pasteurization, losses as high as 3 percent of the total fat churned were observed. The causes of an excessive quantity of fat being lost in the buttermilk are:

(1) Low testing or excessively high testing cream.

(2) Diluting the cream with water or with an excessive amount of starter.

(3) Improper neutralization and pasteurization.

(4) Slow cooling, excessive agitation during cooling, or forgetting to stop the coil when cooling is finished.

(5) Partial churning during pumping.

(6) Churning too soon after pasteurization and cooling, especially during spring and summer.
(7) Not holding cooled cream at low enough temperature after pasteurization.
(8) Churning at too high temperature.
(9) Warming the cream during churning.
(10) Excessive speed of churn.
(11) Overloading the churn.

Any one of these may cause an excessive loss. In an efficiently operated creamery, it should be possible to keep this loss of fat down to nearly 1 percent.

**MOISTURE CONTENT**

The control of the percentage of moisture in butter is important in any creamery, large or small. With modern churns and using good butter making practices it is now possible to control the moisture within narrow limits. A method of calculating the amount of water to add to churnings of partly finished butter has been developed at the Oregon Agricultural Experiment Station. On the basis of an algebraic formula a table has been prepared which shows the amount of water to add to various churnings ranging in size from 300 to 2,000 pounds fat and with moisture contents in the partly finished butter ranging from 13.5 to 16.4 percent when the desired moisture content of the finished butter is 16.5 percent. The table has been found very useful in many of the western creameries.

Not until the butter moisture standard was eliminated in Oregon in 1930 was it common to determine the fat content of the butter made in the creameries. The change to the single (fat) standard resulted in a lowering of the average salt percentage by 0.6 percent and a raising of the average moisture percentage of Oregon butter by 0.6 percent. As the composition of the butter marketed showed considerable fluctuation, it became necessary to assist the buttermakers in their composition control work. Specific directions for analyzing butter for fat, moisture, and salt were outlined. A manufacturer upon request constructed a balance with beams that permit the direct reading of both the fat and moisture percentages. A table was prepared that shows the pounds of fat in different lots of cream varying from 500 to 5,000 pounds with fat contents ranging from 29 to 42 percent, the pounds of butter that can be obtained (22.92 percent overrun) and the pounds of salt that must be added to the butter in each churning in order that the finished butter will contain 2.3 percent salt (allowing for a 0.1 percent loss). The composition of finished butter to be 80.5 percent fat, 16.5 percent moisture, 2.3 percent fat, and 0.7 percent curd.
COMPOSITION

A patent (No. 2,331,656) was granted October 14, 1943 to Conner, Bird, Flakker, and Johnson for "A Method of Controlling the Composition of Butter". The method involves the following steps: "Determining the percentage butterfat content of an unknown volume of homogeneous cream, determining the weight of the churning by churning the cream to the point of 'break' and then reading the liquid level of the buttermilk on a scale calibrated in weight units of the total churning based on the volumetric capacity of the churn, then, from knowledge of the percentage butterfat content and the weight of the churning, determining the weight of the butterfat in the churning, separating the butterfat from the buttermilk, determining the percentages of coloring matter, salt and moisture to be added to produce a uniform composition, then from said percentages and the weight of the butterfat determining the amounts of each to be added to the butterfat and thereafter thoroughly incorporating in the butterfat the determined amounts of coloring matter, salt and moisture."

LEAKAGE LOSS

A large percentage of the butter manufactured in the United States is printed by means of power printers. The butter must possess good "printability." That is, it must have a waxy body and a well-knit texture. It must not be hard and brittle, or greasy and leaky. The moisture droplets must be small and well distributed in the butter. A loss of brine of from 1 to 3 percent on the weight of the butter as the total loss during and subsequent to printing has been reported by butter distributors. With butter at 40 cents a pound, a loss of 1 percent due to brine leakage would amount to $4,000 on 1,000,000 pounds butter. Short-weight butter may be seized by regulatory officials. Work with a number of creameries marketing their butter through a central marketing organization has resulted in a substantial lowering in the leakage losses. It is not uncommon for these losses to range from only 0.1 to 0.5 percent when well-made butter is printed.

Loss of brine during and subsequent to printing is prevented by:

1. Having the cream in the proper physical condition for churning.
2. Placing the right amount of cream in the churn.
3. Revolving the churn at the proper speed.
4. Churning to granules the size of small peas.
5. Using wash water at the proper temperature.
6. Proper distribution of the salt.
7. Working the butter until it is dry, but not so much as to cause salvininess during summer or stickiness during winter.
CONTINUOUS CHURN

The "continuous" method of manufacturing butter is still in the experimental stage. It is claimed for the method that the butter made has a close texture, free from any leakiness, and has a waxy, pliable body. The fat loss in the buttermilk is said to be small. A definite advantage is that the butter can be extruded from the churn and placed in the final package without previous hardening. Another advantage of this method is that yeasts, molds, and undesirable bacteria can be effectively controlled. If this method of butter manufacture is found satisfactory under pilot plant operation, it will be the most outstanding development in buttermaking since H. E. Schuknecht first pasteurized cream in commercial buttermaking almost fifty years ago (1897) in Minnesota.

SELF-CLEANING FARM SEPARATOR

The twice a day disassembling and cleaning of a farm separator may soon be unnecessary if the "self-cleaning" separator now being tested at the University of Illinois proves satisfactory. An Englishman, H. W. Fawcett, has equipped a separator bowl with three ports, located in the bowl wall. These ports, closed when the bowl revolves at separating speed, open when the speed is reduced. When, after using the separator, cleaning solution, followed by a sterilizing solution, is run through the bowl, all milk and cream remnants and slime deposit are removed by the surging action of the solution, and the interior of the bowl is left clean and dry. A dependable supply of hot water must be available. Tests now being made by the Illinois Agricultural Experiment Station will show whether the separator bowl can be satisfactorily cleaned without disassembling it. The research workers will determine if the bowl can be adequately cleaned by this method twice a day for periods extending up to one or two weeks. The preliminary work by Tracy, Hissong, and Herreid shows no significant trend between the bacterial counts of the milk before separation and the counts of the cream and skim milk after separation during a seven-day test involving 14 separations. The counts of the raw milk and the counts of the cream and skim milk have the same relation to each other in the 14 runs. During the test the separator bowl was not disassembled. With the exception of a slight milk stone deposit on the disks, the bowl and parts were free from any milk or cream remnants or slime deposit at the conclusion of the test.

QUALITY CREAM

Good quality cream is fundamental to butter of good quality. It may be said that buttermaking begins on the farm. Cleanliness during production and handling of the milk and cream is necessary and preservation of the quality of the products by proper cooling and storage will
mean greater returns to the producers. Prefabricated milk houses will
soon be available. Automatic electric or gas water heaters are avail-
able at a reasonable price. A good supply of hot water is necessary
on any dairy farm. New types of mechanical refrigerators for farm use
are being developed. One of these new refrigerators has a side-opening
door, thus eliminating any lifting. The compressor is operated by a
1/4 h.p. motor. During cooling, refrigerated water at a temperature
of 33°F. is sprayed on the cans. The smallest cabinet accommodates
four ten gallon cans. Milk may be poured directly through a strainer
into the can. The strainer fits in an opening in the top of the
cabinet. Low-cost refrigerators for use in cooling cream on farms are
being developed. The introduction of these on the thousands of farms
that now have inadequate facilities for cooling cream will be a large
factor in improving the quality of cream marketed. Cream stations
will find the air-cooled cabinet developed by Downs and Yung of the
Nebraska Agricultural Experiment Station satisfactory for storing
cream held for shipment, or they may use the single-can cooler where
a cooling unit is inserted into the can.

TECHNICAL ADVANCES MADE IN THE DEVELOPMENT OF NEW METHODS AND
NEW TYPES OF DAIRY PRODUCTS

Pronounced acceleration in the development of numerous foods
took place during the war period. There was urgent need for foods
that would possess the military characteristics and would be acceptable
by the troops in different parts of the world under varying climatic
conditions. The object was to supply the army with foods that would
possess the qualities of palatability, eye appeal (color, etc.), and
high nutritional value after the period from 6 to 12 months which
elapses before the food is consumed in the field.

Among the dairy products that have been technologically advanced
and manufactured in large quantities during the war period can especial-
ly be mentioned: dry whole milk, dry ice cream mix, bread spread, and
butter oil. Although perfection in the manufacture of these foods has
not been reached, the products have, in general, been quite acceptable
to the Quartermaster Corps.

Dry whole milk to meet the army specifications must have a fat
content not less than 26 percent and a moisture content not above 2.25
percent. The acidity, copper, iron, bacteria, and sediment content
must be quite low.

In a western plant which has manufactured several million pounds
of dry whole milk for military and lend-lease purposes, condensed milk
containing 40-41 percent total solids is sprayed at 140°F. through
a #69 or #72 nozzle into a chamber. The largest size, all stainless
steel drier used at this plant has a drying capacity of 600 pounds
finished product per hour. The packing procedure includes:
(1) "sweeping out" of oxygen between powder particles by carbon
dioxide, (2) vacuum treatment of each container, and (3) addition
of nitrogen gas to each can immediately before sealing.

Electricity from the Bonneville power plant on the Columbia
River is used for the heating of the air used in drying on one of
the driers in an Oregon dry milk plant. It is claimed that this
electric heating unit is the first of its kind in the United States.
The equipment will make an annual power demand of approximately
2,000,000 K.W.H. With this equipment the outgoing hot air is used
partly to heat the ingoing air, thus effecting a saving of over one-
third of the heat units required.

Dry ice cream mix is another product that has been made in in-
creasing amounts during the war period. The Quartermaster Corps
Tentative Specifications (January 1945) require that the product con-
tain not less than 27 percent total fat, not less than 9.75 percent
protein, and not over 2.25 percent moisture. For reconstitution 4\(\frac{1}{2}\)
pounds of the powder is mixed with 7 pints water.

Methods of manufacturing dry ice cream mix will vary in accordance
with the conditions in the various plants and the raw materials avail-
able. Dr. P. H. Tracy of the Illinois Agricultural Experiment Sta-
tion has outlined the following procedure (In Ice Cream Trade Journal,
41, no. 9, 1945):

(1) Combine the milk solids, stabilizer and one-fourth the
sugar to be used together in such proportions as to obtain
the desired ratio of solids to one another. For example,
if you desired to make an ice cream powder which when re-
constituted tested 12 percent fat, 10.8 percent serum solids,
15 percent sugar and 0.24 percent stabilizer you would com-
bine cream, whole milk, sugar and stabilizer together in
such proportions that for every one pound of fat there would
be 0.9 pound of serum solids, 1.25 pounds of sugar, and 0.02
pound of stabilizer.

(2) Preheat to 170° F. for 20 minutes.

(3) Cool and store until sufficient volume is available for dry-
ing.

(5) Preheat to 150° F. In some plants it may be desirable to
add the sugar and stabilizer at this point rather than be-
fore condensing.

(6) Spray a rather coarse particle if this can be done without
too great a sacrifice to plant capacity.
(7) Mix remainder of sugar with dried mix in proper proportion to obtain the desired sugar-fat ratio. In this case this ratio would be 15:12. At the same time the powdered vanilla should be added.

(8) Package and gas in usual manner.

The mix should be made of milk products of high quality. Steps should be taken to reduce copper and iron contamination to a minimum. Government standards such as for sediment, solubility, solids, and bacteria must of course be complied with.

Army spread for bread is a product prepared from butter, cheese curd, and nonfat dry milk solids. It may also contain: not over 0.17 percent vegetable gum, not over 2 percent emulsifying agent, not over 0.1 percent benzoate of soda, not over 0.1 percent antioxidant, and approximately 2 percent salt. In addition not less than 8,500 U.S.P. units of vitamin A shall be added per pound of finished product (Q.M. Corps Tent. Spec., July 1943).

In manufacturing army spread, the ingredients shall be thoroughly mixed and comminuted while heating into a homogeneous mass. The mixture shall be heated to a temperature of not less than 160° F., nor more than 180° F. The containers shall be filled with the product at a temperature not lower than 145° F. and shall be held at a temperature not lower than 142° F. for not less than 20 minutes, the latter holding time to be included in the cooling process.

The finished product shall not oil off when held for 24 hours at 120° F. It shall have a butterfat content of not less than 56 percent, and a moisture content of not more than 29.5 percent.

Carter’s Spread, in accordance with the army specifications, shall be prepared from butter, hydrogenated cottonseed oil, and, in addition, 0.1 percent benzoate of soda, not more than 0.5 percent emulsifying agent, not more than 0.1 percent antioxidant, and approximately 4 percent salt. In addition, not less than 7,500 U.S.P. units of Vitamin A shall be added per pound finished product. The spread must contain not less than 68 percent butterfat.

In manufacturing this product, the butter and vegetable oil shall be melted together, and the other ingredients added to the mixture, the whole being thoroughly mixed into a homogeneous mass. The mixture shall be heated to a temperature of not less than 150° F. nor more than 180° F. and held at a temperature within that range for not less than 10 minutes. The mixture shall then be cooled as rapidly as possible under agitation or any other mechanical means which produce a satisfactory emulsion. The containers shall be filled with the product at a temperature not to exceed 90° F.
The finished product shall have a melting point (Wiley) of not less than 118° F. It shall not oil off when held for 24 hours at a temperature of 110° F. The total fat content shall be not less than 80 percent.

Dairy Spreads utilizing cream, milk, dry milk, condensed milk, cultured milk with added color, vitamins and flavor have been developed during the past two or three years.

One product known as "Dyne" was developed in 1943 by the University of Wisconsin Department of Dairy Industry. Dyne is the collected trademark of the Wisconsin Alumni Research Foundation. Dr. K. G. Weckel, in a private communication, reported that "Dyne" is prepared as follows: "28 percent fat, 19-20 percent solids not fat, using either a condensed product (a mix condensed in the pan) or by mixing whole or skim powder and cream. To the mixture is added 20 percent by weight of cultured buttermilk, 1.3 percent salt and lactic acid (25 grams per 25 pounds total mixture). The product is then pasteurized at 145° for 30 minutes. When the holding period is over, starter distillate is added and the product homogenized at the pressure necessary to impart a slight but definite thickening. It is filled immediately (hot) into containers, which are then cooled by storage in the refrigerator. Upon cooling the product develops a body or 'set'." The label on the container gives the following composition of the product: "Cream, milk, cultured buttermilk, lactic acid, flavor derived from cultured buttermilk, salt, Vitamin A and Vitamin D. Moisture 56 percent, butterfat 26 percent, milk solids not fat 16 percent, salt 1 percent, Vitamin A -- 9,000 U.S.P. units per pound, derived from fish liver oils, Vitamin D -- 3,200 U.S.P. units per pound, derived from irradiated ergosterol."

"Dyne" spread has been sold in half pint milk bottles at 23 cents. The product keeps satisfactorily for two to three weeks.

Several types of commercial butter spreads may be made. Four general types are: (1) whipped butter; (2) a combination of whipped butter and other dairy products, a water-in-oil emulsion; (3) a homogenized oil-in-water emulsion made from butter and other dairy products, and (4) a liquid oil-in-water emulsion discharged under nitrous oxide pressure resulting in a whipped butter spread.

Drs. H. Pyenson and P. H. Tracy of the Illinois Agricultural Experiment Station, in 15, 1943, nos. 9 to 11 of Food Industries give the formulas for "Stabilized, Homogenized Butter Spreads" and "Whipped Butter Spreads."
Examples of stabilized homogenized spread are:

<table>
<thead>
<tr>
<th></th>
<th>(a)</th>
<th>(b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salted butter</td>
<td>55.5 lb.</td>
<td>43.0 lb.</td>
</tr>
<tr>
<td>Cream, 19 percent *</td>
<td>54.7 lb.</td>
<td></td>
</tr>
<tr>
<td>Skim milk</td>
<td>42.2 lb.</td>
<td></td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>2.0 lb.</td>
<td>2.0 lb.</td>
</tr>
<tr>
<td>Gelatin</td>
<td>0.3 lb.</td>
<td>0.3 lb.</td>
</tr>
<tr>
<td>Salt</td>
<td>5.0 lb.</td>
<td>5.0 lb.</td>
</tr>
<tr>
<td>Butter color</td>
<td>75 ml.</td>
<td>25 ml.</td>
</tr>
<tr>
<td>Starter distillate</td>
<td>25 ml.</td>
<td>25 ml.</td>
</tr>
</tbody>
</table>

* The equivalent of heavier cream and skim milk may be used.

DIRECTIONS

Add the gelatin, salt and skim milk powder to the mix at 90° F. Agitate and heat to 150° F. for 30 minutes. Homogenize at 3,500 lb. pressure. Cool, add starter distillate, package and allow to set in refrigerator until firm.

An alternative formula, using heavy cream, contains:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream, 46 percent</td>
<td>98.0 lb.</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>1.7 lb.</td>
</tr>
<tr>
<td>Gelatin</td>
<td>0.3 lb.</td>
</tr>
<tr>
<td>Salt</td>
<td>1.5 lb.</td>
</tr>
<tr>
<td>Butter color</td>
<td>150 ml.</td>
</tr>
<tr>
<td>Starter distillate</td>
<td>30 ml.</td>
</tr>
</tbody>
</table>

REMARKS

The product obtained by this method is very smooth and can be spread easily as soon as it is removed from the refrigerator. It can be packaged hot, directly from the homogenizer, but better results are obtained when packaged after cooling.

Spreads of this type can be made in plants equipped with either a viscosizer or homogenizer.

The butter color can be omitted. The starter distillate is added to improve the butter flavor and aroma, and should be added to the finished product after cooling. There are various commercial products containing coloring and vitamins that may be added to improve the appearance and increase the nutritional value of such spreads.
Since the moisture content is much greater than that of butter, there is a tendency for a slight shrinkage to take place on storage, and properly waterproofed containers, such as the paraffined containers used for cottage cheese, are necessary. A slight syneresis may occur if the spread is not kept under refrigeration.

When properly refrigerated, and when made from high quality products, these spreads should keep well for two or three weeks.

Examples of the whipped butter and butter spread are:

<table>
<thead>
<tr>
<th></th>
<th>Whipped Butter</th>
<th>Whipped Butter Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salted butter</td>
<td>100 lbs.</td>
<td>50 lb.</td>
</tr>
<tr>
<td>Cream, 19 percent*</td>
<td>50 lb.</td>
<td>50 lb.</td>
</tr>
<tr>
<td>Butter color</td>
<td>50 ml.</td>
<td>90 ml.</td>
</tr>
<tr>
<td>Starter distillate</td>
<td>25 ml.</td>
<td>25 ml.</td>
</tr>
<tr>
<td>Salt</td>
<td>8 oz.</td>
<td>6 oz.</td>
</tr>
</tbody>
</table>

* Or the equivalent in cream and skim milk.

**DIRECTIONS**

For the whipped butter, soften to about 65-75°F, so that it is soft enough to work easily. Add the salt and butter color. Whip until the desired overrun (50 to 100 percent) is obtained, then run directly into packages and place in the refrigerator at 40°F to harden.

The butter spread is made by whipping the butter in the same way. Add the starter distillate and salt to the cream, then slowly add this to the whipped butter, and continue whipping until the desired overrun is obtained. The greater the overrun in the whipped butter, the greater will be the overrun in the finished product. The finished spread should test about 50 percent butterfat and 4 percent milk solids-not-fat.

In an unpublished paper, Pyenson and Tracy state the following regarding the food value of butter spreads: "Since these spreads contain only 45 percent to 50 percent of butterfat, their caloric value is less than that of butter. Butter and whipped butter contain approximately 3,470 calories per pound or 103 calories per serving of 1/2 ounce; type 2 spread contains 2,191 calories per pound or 69 calories per 1/2 ounce; and type three and four spreads contain approximately 2,019 calories per pound or 63 calories per serving of 1/2 ounce. Butter normally contains 0.7 percent milk solids-not-fat whereas these spreads contain up to 6 percent of milk solids-not-fat depending on the type of spread. Spreads made as directed are rich in pure milk fat, which is the most digestible of all fats and the best source of body energy obtainable. Butterfat is the only food fat which contains
certain natural elements that are essential for growth and health. These butter spreads besides containing the vitamins A and D contain a liberal amount of the water soluble vitamins such as riboflavin.

Note: These spreads, if sold, may violate the present Federal Food, Drug and Cosmetic Act and perhaps certain state laws.

Butter oil or milk oil is the almost moisture-free milk fat obtained in various ways from cream or from butter. Because of its high food value, it lends itself admirably to overseas shipment. It is also valuable as a product to be stored for use during periods of scarcity of butterfat. A bibliography on butter oil can be obtained from the United States Department of Agriculture, Washington, D.C.

The Quartermaster Corps has no specifications for butter oil but the requirements for the product would be: 0.0 peroxide value, not more than 0.2 percent free fatty acid, and not more than 0.05 percent moisture as determined by the Fischer Titration Method (Special Communication by Lt. R. J. Remaley, Chief, Dairy Products Branch, Q. M.C. Subsistence Research and Development Laboratory.).


This method was developed in New Zealand during the war. The object was to prepare pure dry butterfat on a large scale with equipment obtainable within the country.

Procedure
1. Extrude the butter from a bulk-butter packer into a closed melter-cylinder.
2. Melt the butter, using 1 pound per sq.in. steam pressure.
3. Pump the melted butter to separating cylinders. Gravity separation of serum takes place.
4. Pass fatty portion through a cream separator and then through a pasteurizer to two other separators.
5. The nearly dry fat is run down the steam-jacketed walls of a vacuum pan for drying at a vacuum of 29 inches.
6. Pump the dry fat through a rotary cooler to the filling line.
7. The serum from the separating cylinder and from the first and second series separators is reseparated twice as above.
8. The fat loss amounts to from 0.9 to 1.3 percent of the fat in the butter.
9. The butter fat produced is free from toffee flavor.
10. The dry fat has a moisture content of from 0.02 to 0.04 percent.
11. There is no loss of Vitamin A during processing.
12. The oil is placed in tinned containers and is then stored at 45° F.
The following is a general outline of the procedure for preparing butter oil by one of the methods developed in the United States.

1. Melt the butter.
2. Dilute the melted butter with warm water.
3. Neutralize the free fatty acids.
4. Separate the oil and the serum, using a specially designed separator.
5. Continuously subject the oil to high temperature vacuum steam treatment, steam distillation, and vacuum cooling. This is effective in removing the last traces of moisture resulting in dry oil free from curd.

In a patented process, where cream is used at the beginning, one additional centrifugal separation is employed in the continuous operation to prepare butter oil.

Dehydrated Cheese. A new method of dehydrating cheese has been developed by Dr. G. P. Sanders of the U.S.D.A. Bureau of Dairy Industry. By removal of the water from Cheddar cheese the weight can be reduced about one-third. As dehydrated cheese may be compressed into rectangular blocks, the space conserved, as compared with the original cylindrical form, is from 40 to 46 percent. This was a definite advantage in saving shipping and storage space during the war.

The method developed is as follows:

1. Under an air current cut the edible portion of the cheese into rectangular bars and grate it by means of a mechanical grater into small, thin flakes.
2. Allow flakes to fall onto trays in a uniform layer containing about 0.35 to 0.5 pound of cheese per square foot.
3. A preliminary drying consists of forcing air at a temperature of from 72° to 82° F. and a relative humidity of from 25 to 35 percent or lower between the cheese particles. The moisture content during 30 to 90 minutes is reduced to about 10 percent.
4. Final drying is accomplished by placing the trays on shelves in a tunnel and passing air at a temperature of about 145° F. through the layers of cheese particles. This reduces the moisture content to less than 3 percent in 1 1/2 to 2 hours.
5. After drying, the particles of cheese are cooled in order to solidify the fat.

The two stages of drying could be combined in a continuous process.
Uses. Dehydrated cheese may be used in cooking as for macaroni and cheese. It may also be used with salads, desserts, and in spreads.

Further information on this product may be obtained from the Bureau of Dairy Industry.

Sterilized cream has been made in California plants for several years. The bottled product can be kept at ordinary temperature for many months without deterioration.

Before processing 0.25 percent stabilizer is added. The purpose is to prevent separation during storage. The cream is sterilized at a temperature of from 260° to 280° F. The bottles and caps are steam sterilized under pressure before they are used. The air in the bottling room is cleaned by an electric dust precipitator before it enters the room. Ultraviolet lamps are used in the room as a means of destroying airborne microorganisms. The operators in the bottling room must wear sterilized uniforms, gloves and face masks. Random selected samples from each batch undergo a thorough laboratory examination extending over a period of several days.

Milk pudding is a new development by the U.S.D.A. Western Regional Laboratory, Albany, California. The pudding can be prepared in a few minutes and no heating is required.

Formula:

A. Low-methoxyl pectin 4 grams
   Sugar 4 grams
B. Sugar 40 grams
   Powdered milk 50 grams
   Salt 1 gram
   Flavor -- chocolate, vanilla, butterscotch, or other non-acid flavor materials.

Directions:

To "A" add 2 cups of cold water and stir until the pectin is dissolved (requires 1 to 2 minutes). Add "B" and stir until milk has been completely dispersed, resulting in a smooth texture. Pour into moulds and allow to stand for 5 minutes or longer. Chill if desired.
Canned chocolate-malt flavored milk is now being marketed. One of these products is packed in accordance with a new, patented method. It is a "full cream milk" with sugar, cocoa, malt extract, algae stabilizer, salt, and artificial flavor. The milk, when kept in the hermetically sealed can, will keep well without refrigeration.

Casein fiber, popularly known as casein wool, is now being commercially made in several countries. Its use in the textile industry is still in the development stage. It is uncertain whether casein wool will ever find the same acceptance as rayon. Doctor Whittier of the Bureau of Dairy Industry has pointed out that the annual supply of skim milk, over and above that used for food and manufactured products is 40 billion pounds. This, he stated, is equivalent to one billion pounds of casein. As 1 pound of fiber can be made from 1 lb of casein, 1 billion pounds casein fiber could be produced. This is equal to about one-half the annual world production of rayon and is more than twice the yearly consumption of wool in the United States.

U. S. Patent 2140274 by Whittier and Gould of the Bureau of Dairy Industry is for "a fiber comprising casein, salts of casein, and fat acids and for a fiber in which the aluminum salt of casein is specifically claimed as a component. Any acid-precipitated casein of reasonably good quality may be used in this process, compounds of aluminum or other amphoteric element being added to the alkaline casein solution to increase tensile strength and water-resistance of the fiber. Fat acids are added to overcome the tendency to brittleness or, in other words, to make the fibers flexible. The solution is extruded, with no preliminary aging, through a spinneret into an acid bath containing formaldehyde and substances, such as salts or sugars, to increase the osmotic pressure in the bath and thereby hasten the "setting-up" of the fiber. The fiber is then stretched and wound." A discussion of the advantages and commercial possibilities of casein fiber is outside the scope of the present discussion.

Cheese whey is a potential source of a number of products. In 1944 a total of 141 million pounds of dry whey was manufactured. The product contains lactose, albumin, minerals, and vitamins. The chief use of dry whey is in the preparation of poultry feed. The constituents of whey also find use in the manufacture of human foods, plastics, and pharmaceutical products.

The Bureau of Dairy Industry, U.S.D.A., has been active in conducting research on whey utilization. The chief of the Bureau, Mr. O. E. Reed, has reported on the following:

1. Separation of the whey constituents by a new method based on removal of the lactose from concentrated whey by alcohol.
2. Production of a syrup containing a mixture of dextrose, galactose, and lactose.
3. Utilization of whey solids in the manufacture of taffy, fudge, and caramels. A new type of candy, containing 40 percent whey solids was devised.

4. Incorporation of whey solids in dehydrated pea soup.

5. Preparation of a canned pudding, utilizing whey solids in place of eggs.

6. New products, such as plastics from the lactose in the whey. One of these is polymethylacrylate, which is reported to have the optical properties of the commercial methylacrylate plastics and possessing a high degree of elasticity and solubility which permits its use in impregnating fabrics, in insulation, and numerous other industrial applications.

Another important use of lactose from whey is in the manufacture of the wonder drug penicillin. In 1944 a total of 5 million pounds lactose were used for this purpose.

Of 7½ million pounds lactose manufactured in 1942 about 3 million pounds were used in baby foods, about 2½ million pounds for pharmaceuticals and 2 million pounds were used in various food and industrial products.

It has been reported that lactic acid has been used in the manufacture of rubber. The acid is transformed into methylacrylate and this, in turn, to the synthetic rubber -- lactoprene.

We can look forward to seeing further expansion in the use of whey solids -- through research.

Canned acidophilus milk in pure culture for administering by dairy farmers to new-born calves as a preventive of scours, and similarly by sheepmen for the control of dysentery in new-born lambs, was developed by the dairy department at Oregon State College after Drs. Shaw and Muth of the Veterinary Department had demonstrated the efficacy of the cultured milk for this purpose. Several hundred gallons of this product, placed in 15 oz. cans are sold annually, on a cost basis, by the dairy department to dairymen and stockmen. Full information regarding the preparation of the product is given in Station Technical Bulletin 5 obtainable free from the Oregon Agricultural Experiment Station, Corvallis, Oregon.

Homogenized market milk was first sold commercially in 1935. It is estimated that about 10 to 15 percent of the market milk now sold is homogenized. The industry was confronted with a number of problems incident to the processing, packaging, distribution, laboratory control, cooking, and utilization of returns, of homogenized milk. The extensive work of Trout and associates of the Michigan Agricultural Experiment Station and of other scientists has solved many of the pro-
problems. When appearing on the program of the annual Oregon Dairy Manufacturers' "Dairy Week" in 1942, Doctor Trout discussed the problems and outlined methods for overcoming them. The following is taken from his talk:

1. The chief problem in homogenizing milk is that of the development of rancidity. The milk must be pasteurized at a temperature sufficiently high to inactivate the enzyme lipase, in order to prevent the development of a rancid, bitter, or soapy flavor. The milk must be pasteurized prior to homogenization or immediately following the process. The homogenized, pasteurized milk must not be contaminated with raw milk.

2. Sediment in the bottom of the container is another problem. The sediment consists largely of milk cells, milk solids, colloidal dirt, and some milk fat. It is similar to separator slime. Clarification of the milk by a centrifugal clarifier will overcome sedimentation.

3. Homogenization may cause an increase in bacterial count as determined by the plate method. If properly washed and sterilized, the homogenizer is not a factor in increasing the count. The increase is due to the breaking up of clumps and chains of bacteria during homogenization.

4. A cream plug may form on the surface of the milk. The milk may be improperly homogenized, or non-homogenized milk may have been added. With proper homogenizing a cream plug will not form.

5. Foaming may occur during bottling of homogenized milk. Carrying a high head in the cooler trough and bottling supply tank, and eliminating air leaks in the lines will aid in overcoming this difficulty.

6. To prevent seepage around the cap seat, bottles may be filled to within one-quarter inch of the cap seat. Proper refrigeration of the bottled milk at all times is necessary. Freezing of the milk must be prevented.

7. When testing homogenized milk for fat by the Babcock method, follow the correct procedure, but add the acid in three installments and mix thoroughly and longer than usual before centrifuging.

8. Homogenized milk may sometimes curdle when used in cooking. It is apparently more sensitive to heat than is non-homogenized milk. This may be an advantage with some forms of cookery.
9. As separation of fat from homogenized milk is difficult, daily surpluses should be kept to a minimum. Unused homogenized milk may be successfully used for buttermilk, cottage cheese, or ice cream.

Vacreation of cream for butter was studied by the Iowa, Manitoba, and Oregon Experiment Stations. The method, which is a triple-treatment process of (1) quick-time pasteurization, (2) partial distillation and removal of certain volatile products, and (3) cooling, all under a partial vacuum ranging from about 6 inches to 28 inches, was found to have a beneficial effect on butter quality when good cream was used at each of these experiment stations. The method was found to be efficient in destroying bacteria.

Vacreation of milk for cheese and vacreation of ice cream mix was found satisfactory at the Oregon Agricultural Experiment Station in preliminary tests made by Mr. R. P. Robichaux.

Condensing milk with the Vacreator is a new development at the Oregon Agricultural Experiment Station. Although the Vacreator* was designed by Murray and Board for the specific purpose of pasteurizing and conditioning cream and other milk products, it was found that the Vacreator could be used as an efficient milk condenser. With the "Baby" model Vacreator it was possible to remove 500 pounds of water per hour from the milk and with the "Junior" machine 1,000 pounds per hour could be removed. The condensed milk had an excellent flavor. Oregon Agricultural Experiment Station Bulletin 430, by G. H. Wilster gives the results of the research and the application of the method to the preparation of ice cream mix. See Food Industries, 17, October, 1945, and Ice Cream Field, 46, November, 1945.

Frozen concentrated milk appears to have some market possibilities in areas where fluid milk is scarce. It also would be satisfactory to use on ocean going ships. Studies during recent years on the manufacture of frozen concentrated milk indicate that a product which keeps well and reconstitutes satisfactorily can be made. Messrs. Doan and Leeder of the Pennsylvania Agricultural Experiment Station after having conducted research on the problem of freezing milk condensed to one-third its volume suggested (Food Industries, 16, 562, 1944) the following manufacturing procedure: Clarify high quality milk, pasteurize at a high temperature, condense, homogenize, freeze in ice cream freezer (preferably continuous), place in packages, finish freezing in a room at --10°F. They stated that "The frozen concentrated milk is defrosted and reconstituted to the fluid state by undisturbed thawing in hot water. This results in a fluid milk having properties

* "Vacreator" is the registered trademark designating the Murray vacuum pasteurizers.
which the average consumer would find difficulty in distinguishing from those of fresh fluid milk."

This presentation would not be complete without briefly referring to several other important developments in the field of dairy technology.

Short-time pasteurization of market milk has gained in popularity in recent years. All-automatic machines, utilizing either hot water or electricity as a heating medium, is a marvelous improvement over the milk pasteurizers that were in use 20 to 30 years ago.

Vacuum treatment of market milk prior to short-time pasteurization was found beneficial by the New York (Cornell) Experiment Station in preventing the development of an oxidized flavor in milk and also in preserving the Vitamin C content of the milk.

Square Glass Milk Bottles have become popular owing to the smaller space this shape of bottle occupies in a household refrigerator.

Paper milk containers have come into use since 1929. They are rapidly gaining in popularity. In a study by Drs. Prucha and Tracy of the Illinois Agricultural Experiment Station, it was found that after four years of using glass and paper bottles at intervals, 95 percent of the consumers preferred the paper bottle. The investigation showed that paper milk containers are sanitary as well as practical for fluid-milk distribution. (Agricultural Experiment Station, Bulletin 495, University of Illinois, Urbana, Illinois).

In the cheese industry important developments have been (1) wider use of pasteurization of milk to be used for cheese, (2) curing of cheese in cans, (3) merchandising cheese in transparent wrapping material.

The field of cheese manufacture, including the ripening of cheese, offers an opportunity for unlimited research.

In control work the greatest development in recent years is perhaps the application of the phosphatase test for checking on the efficiency of pasteurization. Recently Sanders and Sager of the U.S. Bureau of Dairy Industry have modified the phosphatase test as used for milk so that it can be used with cheese to determine whether the milk used had been adequately pasteurized. (Bureau of Dairy Industry, U.S. Department of Agriculture, Washington, D.C., Circular of Information no. 22, May 1945. See also J. Milk Technol., 9 (1946), May-June, p. 171-2.)
THE OREGON PROGRAM OF LICENSING CHEESE-MAKERS,
BUTTER-MAKERS AND PASTEURIZER OPERATORS

The licensing of cheese-makers, butter-makers, and pasteurizer operators is an important link in Oregon's dairy products quality improvement program. A law which provides for the licensing of cheese-makers and butter-makers has been on the statute books since 1917. In 1939 an amendment was made to this law requiring the issuance of licenses upon the passing of an examination conducted by the Oregon State Department of Agriculture. This provision greatly strengthened the law and has made it effective.

The production of Cheddar cheese has trebled since 1917. The average yearly production in recent years was nearly 30 million pounds. Butter production has doubled and reached 32 million pounds prior to the war. Inasmuch as during the prewar years, approximately 75 percent of the cheese and 33 percent of the butter manufactured was sold in California in competition with cheese and butter from a number of other states, dairy leaders in Oregon have recognized that it is necessary to market only products of a high and uniform quality, of correct composition, and possessing good keeping properties.

The compulsory milk and cream grading law enacted by the state legislature in 1937 provides for the grading of milk and cream when received at the factories and creameries and also provides for the licensing of the persons who are doing the grading, as well as for payment for the milk and cream in accordance with quality. Inferior quality milk and cream must be denatured by the addition of a red coloring matter, and must be tagged and returned to the place of origin. In other words, milk and cream unfit for human consumption cannot be sold at manufacturing plants in the state. The licensing of the men in the plants who are doing the manufacturing work was deemed necessary in order to raise the standard of proficiency of these men and for the manufacture of uniform products of correct composition.

These two laws, then, are very necessary in Oregon's program of orderly marketing of dairy products.

In 1945 a new law pertaining to the pasteurization of milk and milk products and licensing of pasteurizer operators was passed. With reference to the licensing provision the law states that: It shall be unlawful for any person to be in charge of, supervise, direct, or engage in the operation of any pasteurization equipment unless he shall first have procured from the State Department of Agriculture a pasteurizer operator's license. It further provides that a pasteurizer operator's license shall be issued by the department to any person who shall apply for it in writing and pass satisfactorily an examination including an actual demonstration of his ability to operate pasteuriz-
ation equipment in compliance with the provisions of the law and regu-
lations pertaining thereto. The license is not transferable and is
valid for one calendar year. The annual fee for the license is one
dollar. A permit to operate pasteurizing equipment for a limited
time may be granted by the department.

THE LAW PROVIDING FOR LICENSING OF BUTTER- AND CHEESE-MAKERS

The revised law as enacted in 1939 is as follows:

"For the purpose of this chapter of the Oregon Compiled Laws
the term butter-maker and cheese-maker shall respectively mean and
include any person employed in, engaged in, acting in or who may be
employed in any butter or cheese factory who has charge of any super-
vision over the actual process of manufacturing butter or cheese, but
shall not include a person employed in the butter or cheese factory
for the purpose of aiding or assisting in the manufacture of such
products. This chapter of the Oregon Code shall not affect a person
making up a product produced on his own farm.

"It shall be unlawful for any person to engage in the manufacture
of butter or cheese as a butter-maker or cheese-maker as above de-
finied unless he shall first have secured a license from the State
Department of Agriculture. Such license for butter or cheese-makers
shall be issued by the department under certain rules and regulations
as it shall prescribe relating to the qualification of applicants
for securing such license. Such qualification shall include among
other things previous record in operating and keeping in sanitary
condition the butter or cheese factory in which he has been employed.
The State Department of Agriculture shall also by regulation require
the written and oral examination of any applicant for either or both
a butter-maker's or cheese-maker's license in this state. Such rules
and regulations shall be published in pamphlet form as prescribed by
the Department of Agriculture statute.

"Application for a butter-maker's or cheese-maker's license shall
be made upon an application blank furnished by the State Department of
Agriculture. Upon receipt of any such application the department may,
in its discretion, issue a permit to such applicant to carry on the
work of butter-maker or cheese-maker for such period as may be pre-
scribed therein not to exceed 60 days. Such permit shall have the
full force and effect of a license to carry on the work of a butter-
maker or cheese-maker during the period mentioned therein. At the
time such permit is issued the department shall furnish to the appli-
cant the rules and regulations incident to securing a license and also
suggestions relating to the proper method of operating butter or
cheese factories.

"Each application for such license shall be accompanied by a fee
of $1.00 payable to the Department of Agriculture of the State of
Oregon and no license shall be issued until such fee has been paid to
said department, by which it shall be transmitted to the State Treasur-
er to be deposited in the Department of Agriculture account to be used
by the department toward the payment of salaries, costs, and expenses
in carrying out the provisions of this act. Such money shall be
drawn upon vouchers with the approval of the Director of Agriculture
endorsed thereon and audited by the Secretary of State, who shall
draw his warrant on the State Treasurer. In case license is refused
the fee accompanying such application shall be returned by notifica-
tion of refusal.

"Each butter-maker's or cheese-maker's license shall be subject
to revocation by the State Department of Agriculture if the butter-
maker or cheese-maker, as the case may be, has violated any of the
rules and regulations prescribed by the department, or has violated
any of the laws of the State of Oregon in relation to milk or cream,
or milk and cream products.

"Each butter-maker's or cheese-maker's license shall expire on
the first day of July next succeeding the day of its issue.

"The State Department of Agriculture shall make such rules and
regulations as may be necessary to carry into effect the provision
of this chapter of the Oregon Compiled Laws and for the government of
licenses under this chapter.

"Any person violating any of the provisions of this chapter of
the Oregon Compiled Laws shall, upon conviction thereof, be fined not
less than $25.00, nor more than $150.00, for each violation of this
chapter."

QUALIFICATIONS AND REQUIREMENTS FOR CHEESE-MAKERS'
AND BUTTER-MAKERS' EXAMINATION

In accordance with the law, the Division of Foods and Dairies
of the Oregon State Department of Agriculture has prescribed the
following regulations for the examinations:

CHEESE

1. A knowledge of the following Oregon laws:
   Sanitary regulations.
   Miscellaneous provisions relative to milk and dairy products.
   Licensing of butter and cheese makers.
   Duties of the Department of Agriculture in reference to Foods
   and Dairies.
   Oregon Food Act.
   Milk container brands.
Registration of private brands.
Registration of private brands for containers.
Milk, cream, and butter grades and licensing of graders.
Purchase of milk and cream standard glassware.

2. Ability to perform satisfactorily a practical analysis of cheese for composition, fat, and moisture.

3. Ability to demonstrate the methylene blue test and interpret its results.

4. Ability to demonstrate the fermentation curd test.

5. Ability to demonstrate satisfactorily the judging of cheese as to quality.

6. A thorough practical knowledge of the fundamentals of cheese-making, especially:
   - The effect of the quality of milk on the finished cheese.
   - Sanitation of cheese factories.
   - Composition of milk.
   - Preparation of starter.
   - Rennet and factors affecting its use.
   - Acid control.
   - Composition control.
   - Pasteurization of milk as used for cheese-making.
   - Primary knowledge of yeasts, molds, and bacteria and how to control them.
   - Common cheese defects, their cause and correction.

7. At least one year practical experience in a cheese factory.

8. Ability to demonstrate practically, the proper operation of the Babcock test unless the applicant has an Oregon license to operate the same.

9. Ability to calculate practical dairy arithmetic problems such as the value of milk and dairy products when weight, test, and values are given; standardization of milk for composition control; value of spillage and fat leakage losses, etc.; also the calculation of cheese yields.
BUTTER

1. A knowledge of the following Oregon laws:
   - Sanitary regulations.
   - Miscellaneous provisions relative to milk and dairy products.
   - Licensing of butter and cheese makers.
   - Duties of the Department of Agriculture in reference to Foods and Dairies.
   - Oregon Food Act.
   - Milk container brands.
   - Registration of private brands.
   - Registration of private brands for containers.
   - Milk, cream, and butter grades and licensing of graders.
   - Purchase of milk and cream standard glassware.

2. Ability to perform satisfactorily a practical analysis of butter for composition.

3. If applicant does not possess a butter grader's license, he must give satisfactory demonstration of the ability to grade the same.

4. A thorough practical knowledge of the fundamentals of butter-making especially:
   - Neutralization and acid standards.
   - Neutralization problems.
   - Pasteurization of cream.
   - Preparation and use of starter.
   - Preparation, care, and cleansing of equipment.
   - Control of butter composition.
   - Common defects in butter and method of overcoming them.
   - Primary knowledge of yeasts, molds, and bacteria and how to control them.

5. At least one year practical experience in a creamery or other acceptable dairy manufacturing plant.

6. Ability to demonstrate practically, the proper operation of the Babcock test unless the applicant has an Oregon license to operate the same. In either case the butter-maker must possess knowledge of the proper method of testing buttermilk for fat.

7. Ability to run quick tests for acidity.

8. Ability to calculate practical dairy arithmetic problems such as overrun calculations; the value of overrun losses; spillage losses; and the value of dairy products when weight, test, and unit values are given.
Examinations will be both written and oral. Ability to spell and use correct English will not be considered.

Directions as to how and where to obtain the above information will be sent anyone wishing it by addressing the Division of Foods and Dairies, State Department of Agriculture, Salem, Oregon.

METHOD OF CONDUCTING THE EXAMINATIONS

All the examinations are held in the Agricultural Building occupied by the State Department of Agriculture at Salem, Oregon. The examination committee has consisted of a member of the staff of the Division of Foods and Dairies, State Department of Agriculture, a member of the industry, and a member of the staff of the Department of Dairy Husbandry, Oregon State College.

The oral examination is divided into two parts, taking about one-half hour for each. One part covers the Oregon laws as indicated in the requirements above, and the other covers the practical manufacture of cheese or butter. The plan has been to call in the applicants before the examining board of three men one at a time and quiz them for 30 minutes over the laws. Later they are given a half-hour quiz over the manufacturing methods. It is believed that this oral examination is the most important part of the whole examination. An applicant may not be able to express himself clearly in a written examination. He is usually able to answer questions verbally, provided of course he has a fair knowledge of the subject.

The questions asked are in all cases fair. No attempt is made to confuse the butter-maker or cheese-maker appearing before the committee, and only practical questions are asked. The examining committee does not expect the applicant to answer all questions, but there are a number of questions that should be answered correctly by all applicants. For instance, the committee expects all the applicants to have a fundamental knowledge of the sanitary regulations pertaining to cheese factories or creameries as well as a knowledge of the important tests used in grading milk. In view of the information available on the subject, the committee has also felt that applicants should know the correct methods to use for standardizing milk, for preparing starter, for pasteurizing milk, and for controlling the composition of cheese or butter. A lack of knowledge of the state and federal standards governing the composition of cheese or butter or standards for these products, is inexcusable.

Each applicant has been required to solve practical dairy arithmetic problems common in cheese factory or creamery operation. He has also been given between 100 and 200 true or false questions, which require the marking with a plus or zero sign for an answer.
In the event an applicant fails in the examination he is given an opportunity to appear again for another examination. During the past, examinations have been held twice a year. It is contemplated to give the examinations four times a year, or oftener if necessary.

The committee has refrained from recommending to the Department of Agriculture that a license be issued unless it is reasonably sure that the cheese-maker or butter-maker is sufficiently well informed to manufacture cheese or butter without getting into serious quality and composition difficulties. In some cases it has been necessary for the applicant to appear for the examination two or three times. About one-half of the men who have appeared have passed the first time. The reason for failure generally has been carelessness in preparing for the examination by not studying the laws and regulations, and bulletins and manuals dealing with the practical manufacture of cheese or butter.

A summary of the results of the butter- and cheese-makers' examinations as conducted under the present law as enacted by the 1939 legislature is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Butter-makers</th>
<th>Cheese-makers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total taking examination</td>
<td>85</td>
<td>38</td>
</tr>
<tr>
<td>Total passing first examination</td>
<td>48</td>
<td>16</td>
</tr>
<tr>
<td>Total failing on first examination</td>
<td>37</td>
<td>22</td>
</tr>
<tr>
<td>Failed twice</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Passed on second examination</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Passed on third examination</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Reason for some of the failures is best shown by the results of March, 1941, butter-makers' examination:

<table>
<thead>
<tr>
<th>Laws and Regulations</th>
<th>Oral B. making</th>
<th>Written B. making</th>
<th>Lab. Pract.</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>P</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>P</td>
<td>P</td>
<td>F</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>P</td>
<td>P</td>
<td>F</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>P</td>
<td>F</td>
<td>P</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>P</td>
<td>P</td>
<td>F</td>
</tr>
<tr>
<td>P</td>
<td>F</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

P = Pass.
F = Fail.
There was some fear at first that the committee would be unreasonable in its requirements. It is doubtful now if there is a single person in the industry who is not thoroughly sold on Oregon's program of licensing butter-makers and cheese-makers.

A number of persons representing the industry have participated in giving the examinations. They have even proclaimed that they would not care to hire some of the butter-makers or cheese-makers who have failed during the examination once, twice, or even three times. They know that it is not necessary to possess a degree from a college or university in order to pass the examination, but they know that any cheese-maker or butter-maker who has prepared himself for the examination and who has had proper experience in a plant can pass the examination. It is recognized, however, that the attendance at college or university special dairy courses where the cheese-makers or butter-makers can obtain practical information is of great value in the training of young men for the cheese-making or butter-making profession.

It should be pointed out here that the cheese-makers or butter-makers who held a license prior to 1939 have not been required to take the examination. Most of those who have appeared for the examination have therefore been young men who have worked as helpers in creameries or cheese factories.

WHAT WILL BE THE EFFECT OF THE LICENSING LAW?

The dairy leaders who suggested that cheese-makers and butter-makers submit themselves to an examination prior to obtaining a license had in mind the gradual raising of the standards of proficiency of the cheese-makers and butter-makers as part of a long-time program of quality and composition standardization.

The proper enforcement of the law should:

1. Encourage young men to acquaint themselves with the laws that pertain to sanitation, grading, testing, and composition standards for milk, cheese, and butter.

2. Stimulate in assistant cheese-makers and butter-makers a desire to obtain a thorough knowledge of all phases of the manufacture of cheese and butter.

The ultimate goal is:

1. To raise the general standard of proficiency of the Oregon butter-makers and cheese-makers.

2. To manufacture the highest quality cheese and butter of correct composition.
3. To increase the demand for Oregon cheese and butter in out-of-state markets.

4. To increase the returns to the Oregon dairy farmers.

**LICENSING PASTEURIZER OPERATORS**

The applicant for a license must satisfy the examining board that he has a good knowledge of the following:

1. The law and regulations under which license or permit is granted.

2. Bacteria, yeasts and molds -- what they are; where they come from; what they do; and how they may be controlled.

3. Flavor defects in milk or cream -- their causes and control.

4. Pasteurizing and cooling.

5. Cleaning and sterilizing equipment and utensils used in the pasteurizing room.

6. Tests and problems:
   a. Reading knowledge of standard plate count, direct microscopic count, and phosphatase test.
   b. Ability to demonstrate Babcock fat test and acid test.
   c. Ability to work problems in
      (1) Standardization of milk and cream;
      (2) Neutralizing cream.

A list of the publications such as extension bulletins, manuals, etc., which contain information on the above may be secured from the State Department of Agriculture by each applicant for a license.

The method of conducting the examination is as follows:

The State Department of agriculture will appoint an examining board whose duty it will be to examine each candidate. The board will, at the conclusion of the examination, file with the State Department of Agriculture a report of the results of the examination. Only two grades will be given: (1) 75 to 100 - Pass; and (2) less than 75 -- Fail. Those who fail may present themselves for a re-examination at such time and place as may be scheduled by the department. They must again take the complete examination.

The examining board shall consist of three men. One shall be a member of the Oregon market milk industry selected by the State Department of Agriculture, one shall be a member of the staff of the Division
of Foods and Dairies, State Department of Agriculture, and one shall be a member of the Department of Dairy Husbandry at Oregon State College or a nominee by the head of the dairy department.

The examination shall consist of:

1. An oral examination.
2. A written examination.
3. A demonstration of the candidate's ability to operate a pasteurizer.

Part three shall be supervised by the Chief of the Division of Foods and Dairies or his deputy.

Candidates for the license must apply to the State Department of Agriculture at least 15 days before the examination is to be given for admission to the examination. On an appropriate form he (or she) must indicate the steps taken to obtain the information necessary in order to meet the six above listed requirements.

VACREATION OF CREAM, MILK, AND ICE CREAM MIX
AND CONDENSING MILK WITH THE VACREATOR*

The process of vacreation had its birth in New Zealand, a country known for its well advanced dairy industry and the high quality of the butter and cheese manufacture. It was developed by H. Lamont Murray, the inventor of the Vacreator, and F. S. Board. The term vacreation applies specifically to the pasteurization and treatment of milk, cream, and other milk products. It is a relatively new process.

Through Murray's long experience in the manufacture of condensed milk in New Zealand he realized that the boiling of milk under a partial vacuum was effective in eliminating feed flavors. In a declaration he stated that, "In the year 1923 I gave thought to the extraction of feed flavors from cream intended for buttermaking and toward this end devised a method and apparatus for the continuous treatment of a flow of cream while boiling in vacuo".

* Vacreator is a Trade Mark Reg. U.S. Pat. Off., in Canada and other countries.
WHAT IS VACREATION?

It is a three stage process that consists of:

1. Heating the milk, cream, mix or other milk product, instantaneously, by mingling with steam under a reduced pressure, in the first chamber, to the desired pasteurizing temperature.

2. Admitting the product to the second chamber, maintained at a lower pressure, where boiling occurs, for removal of gases and volatile substances and excess steam to the water condenser.

3. Briefly exposing the product in the third chamber maintained at nearly complete vacuum, where boiling again occurs, for additional removal of water vapor and volatile products.

Vacreation, then, means effectively pasteurizing milk, cream, or other dairy products, under reduced pressure by steam, followed by a removal of a part of the water vapor as well as volatile substances, and finally reducing the temperature of the product quickly in a vacuum chamber to about 110°F.

THE DEVELOPMENT OF THE PROCESS

Murray and Board did not develop the process overnight. It may be of interest to briefly outline the several steps in the evolution of the vacreation process. They were:

First stage: Continuously passing hot flash pasteurized cream through a vessel under vacuum.

Second stage: Introducing steam into the flow of flash pasteurized cream on its way to the vacuum chamber so as to obtain steam-distillation.

Third stage: Elimination of the conventional flash pasteurizer by addition of a direct steam contact section to the vacuum chamber, thus obtaining vacuum pasteurization and steam-distillation in the one unit.

Fourth stage: The addition of a second and high vacuum chamber wherein to obtain further distillation and cooling.

The recently perfected machine of stainless steel construction is now extensively used for vacreating cream for butter in New Zealand, Australia and South Africa.
OPERATION OF THE VACREATOR

The Vacreteator constitutes a combination of: (1) vacuum pasteurizer, (2) steam distillation chamber, and (3) high vacuum chamber. The end result obtained from vaoreation is more than a summation of the results of the component units, were these to be operated separately.

In the accompanying illustration is shown the flow cycle of the vacuum process when the Vacreteator is used as a pasteurizer.

The dairy product -- milk, cream, ice cream mix, etc. -- delivered by the feed pump "X" is admitted by a float - controlled valve to a perforated spray pan located in the top of the first, or pasteurizing, Chamber, "A". It falls in droplets from the spray pan and is heated by direct contact with steam admitted through valve "B". The pressure in the pasteurizing section is below atmospheric pressure and may be held at any desired point, usually between 11 inches and 6 inches of vacuum, thus maintaining any temperature from 190° to 200° F. Lower temperatures may also be used as desired, as when pasteurizing milk for cheese. In the bottom of the pasteurizing chamber is located a spring-actuated equilibrium valve "C". The second chamber "E" and the pipe "D" are kept at a reduced pressure of about 15 to 25 inches of mercury by the action of the ejector condenser "F", depending on the product being treated. The relative pressures in "A" and "B" are controlled by the adjustment of the tension on the equilibrium valve "C".

The product on reaching the bottom of the pasteurizing chamber "A" is drawn past the equilibrium valve, passes up the pipe "D" and is discharged tangentially into the cylindrical chamber "E". Under the influence of the lower pressure in the uptake pipe "D" in chamber "E", the product boils at from 160° to 180° F., and releases as water vapor a portion of its water content to the ejector condenser, the water vapor carrying with it other volatile substances present in the product. The product through pipe "D" into a third chamber "I", where a still higher vacuum, usually 28 or 281/4 inches, is maintained. The product enters this final chamber, loses more water vapor and volatile substances and is cooled in the process to about 110° F. The product is pumped from the bottom of the last chamber to the cooler by a multistage centrifugal pump "Z".

The amount of steam passing through valve "B" is in excess of that necessary to raise the temperature of the product to the pasteurizing temperature. This excess of steam aids in the freeing and carrying away of certain volatile substances from the product, such as may be imparted by feed and weeds. The rise in temperature of the cold water, forced through the ejector-condenser by pump "Z", is an indication of the amount of water vapor drawn off from the hot product in the reduced pressure chamber.
At present Vacreators, constructed from stainless steel, are made in three sizes. The specifications for the machines are as follows:

<table>
<thead>
<tr>
<th>Capacity, pounds per hour</th>
<th>2,500 (cream)</th>
<th>5,000 (cream)</th>
<th>15,000 (milk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When pasteurizing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6' 6&quot;</td>
<td>6' 9&quot;</td>
<td>6' 6&quot;</td>
</tr>
<tr>
<td>Height</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>3' 0&quot;</td>
<td>4' 6&quot;</td>
<td>10' 6&quot;</td>
</tr>
<tr>
<td>Depth</td>
<td>2' 10&quot;</td>
<td>3' 0&quot;</td>
<td>3' 3&quot;</td>
</tr>
<tr>
<td>Water required (U.S.</td>
<td>18-24</td>
<td>29-42</td>
<td>35-51</td>
</tr>
<tr>
<td>gallons per minute)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam required (lbs. per</td>
<td>120-160</td>
<td>120-160</td>
<td>120-160</td>
</tr>
<tr>
<td>1,000 lbs cream - less</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>for vacreating milk or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mix)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cream discharge pump</td>
<td>2 hp</td>
<td>2 hp</td>
<td>3 hp</td>
</tr>
<tr>
<td>Water pump</td>
<td>3-5 hp</td>
<td>5 hp (2)</td>
<td>7 1/2 hp</td>
</tr>
<tr>
<td>Shipping weight (without</td>
<td>1,350 lb</td>
<td>2,000 lb</td>
<td>3,700 lb</td>
</tr>
<tr>
<td>motor)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VACREATION OF CREAM FOR BUTTER

The first Vacreator on the American continent was received from New Zealand and installed in the dairy products laboratory at the Oregon Agricultural Experiment station in September 1938. A report covering a study of 86 churnings of butter made from cream pasteurized by the usual vat method and 86 churnings made from cream pasteurized by the new method was published. It was found that "Vacreation resulted in increasing the average score of the butter when fresh 0.33 point", and "The vacreation method of pasteurization was found to be more efficient in killing bacteria than the coil vat method at the temperatures used." Vacreators were also installed by the dairy departments of the University of Manitoba and Iowa State College. Experimental churnings were made. Results obtained in Manitoba showed that "Of the 153 direct comparisons made in this study between butter made from pasteurized and vacreated cream, all but eight of 145 are in favor of the vacreated on the basis of flavor scores," and it was reported that the Vacreator was an efficient pasteurizer. The Iowa results show that "the vacuum pasteurization of good quality cream gave butter of significantly higher score than vat pasteurization of portions of the same cream." There was an average difference of 0.97 point in score in favor of the butter made from vacuum pasteurized cream. It was also found that "No deleterious heated or cooked flavors are introduced as a result of the high temperature of pasteurization."
VACREATION OF MILK FOR CHEDDAR CHEESE

The possibility of vacreating milk for cheese was considered at Oregon Agricultural Experiment Station. It was known from previous tests with cream that this continuous method of pasteurization and cream treatment resulted in:

1. Efficient destruction of microorganisms.
2. Removal of objectionable feed and weed flavor.
3. Reduction in the temperature of the pasteurized product by about 90°F by vacuum cooling.

If the same could be accomplished when vacreating milk for cheese perhaps a product of a superior quality could be manufactured.

In preliminary tests it was found that when a temperature of 160°F to 165°F was maintained in the first, or pasteurizing chamber, without any retarding, the enzyme lipase was not destroyed. The flavor of the cheese became slightly rancid during storage. A method of preheating prior to vacreation was therefore tried. It was found that preheating the milk by means of a tubular heater to at least 145°F followed by vacreation using a pasteurization temperature of 165°F was effective in controlling the rancid flavor development.

With a bacterial count in 15 batches of raw milk ranging from 2,500 to 4,800,000 per milliliter and a geometric average of 75,500, the numbers of bacteria in the vacreated milk ranged from less than 100 to 56,000 per milliliter.

A total of 24 batches of cheese was manufactured from 12 lots of commercial grade milk. Twelve batches were manufactured from raw milk and twelve batches were made from vacreated milk. These were split batches.

The cheese was scored by the federal grader at Portland, Oregon. Of the 12 batches of vacreated milk-cheese 11 scored higher than the raw-milk cheese. The scores of the raw-milk cheese ranged from 88 to 91, and averaged 89.87. The scores of the vacreated milk-cheese ranged from 89.50 to 92, and averaged 90.92. Thus, the average score of the cheese from the vacreated milk was 1.05 points higher than that of the cheese made from raw milk.

Since these experiments were conducted large size Vacreators of a capacity of 15,000 pounds milk per hour have been installed in several cheese factories. It is reported that Cheddar cheese of excellent quality is being manufactured by these factories. This vacuum method of pasteurization is proving effective in eliminating onion and other weed flavors from otherwise good quality milk.

The war interrupted the cheese experiments at Oregon State College.
It is planned to do further research on the vacreation of milk for cheese.

MANUFACTURE OF ROQUEFORT-TYPE OF CHEESE FROM VACREATED MILK

A method of milk treatment in which the Vacreator is used that would have the same beneficial effect during the ripening of Roquefort-type cheese as homogenization was developed by Fabricius and Nielsen at the Iowa Agricultural Experiment Station. By preheating the milk to 110° F., followed by vacreation, using a temperature of 165° to 170° F., in the Vacreator the lipolytic activity of the milk was stimulated similar to that caused by homogenization. This favored the development of desirable flavor in the cheese. Competent judges pronounced the Roquefort-type cheese, made from Vacreator-treated milk, excellent in quality.

VACREAT ION OF MAR1T MILK AND CREAM

No experiments have been made so far on vacreation of market milk or cream. This method of milk and cream treatment offers some possibilities. At present the two accepted methods of pasteurization of market milk and cream are: (a) 143° F. for 30 minutes and (b) 160° F. for 15 seconds.

Tests to determine the effect of vacreation when using different temperatures in the pasteurizing section on the destruction of bacteria and enzymes are now underway in the dairy manufacture’s laboratories at the University of Illinois Agricultural Experiment Station.

VACREATION OF ICE CREAM MIX

As ice cream mix had generally been pasteurized at from 155° to 160° F., for 30 minutes prior to homogenization, it was with some skepticism that this method of high-temperature, vacuum pasteurization of ice cream mix was tried by the Oregon Agricultural Experiment Station. It was expected that the heat treatment, even at 190° to 200° F., might cause a caramel or butterscotch flavor in the mix, and that the whipping property of the mix would be injured. It was also suspected that the ice cream would have a weak body and probably a poor melt-down characteristic. As the mix would emerge from the vacuum pasteurizer at a temperature of about 110° F., it would be necessary to heat the mix again if homogenization were to follow pasteurization.

It was decided, however, to study the effect of this method on the quality of ice cream. The procedure decided upon consisted of the following steps:
1. The ingredients for the mix -- cream, milk, dry milk, sugar, whole egg, gelatin -- were blended in a coil vat and heated to a temperature of 150° F.

2. The temperature of the mix was maintained at 150° F. while being homogenized. Homogenization consisted of applying a pressure of 2,500 pounds per square inch.

3. The homogenized mix was discharged into a surge tank.

4. The homogenized mix was vacuum pasteurized as follows:
   - First chamber (6½ inches vacuum) 2000 F.
   - Second chamber (20 inches vacuum) 161° F.
   - Third chamber (28 inches vacuum) 100° F.

5. The pasteurized mix was cooled to 35° F. on a surface cooler and was then stored in an insulated tank until used.

The mix treated by this method, where homogenized mix was vacuum pasteurized, was compared for flavor, body, bacterial content, and whipping property, with a mix processed by the usual method of vat pasteurization followed by homogenization and cooling. The results obtained were surprisingly good. In a considerable number of comparisons, involving split batches, it was found that the mix treated by the new method had a more palatable flavor, a less viscous body, and a better whipping property than the mix treated by the usual method. The vacuum pasteurized mix had a low bacterial content.

The process was also found satisfactory at the Iowa Agricultural Experiment Station. It was reported that "vacreation of ice cream mix improved the flavor of ice cream when scored fresh", and "there was less tendency for vacreated mix ice cream to develop a stale, oxidized, or metallic flavor". In this work homogenization followed vacuum pasteurization.

As a result of the tests made at Corvallis during the year 1939, it was decided to use the vacreation method as a standard procedure for all ice cream mix prepared in the Oregon State College dairy products laboratory. The results of this application during the past five years have been very satisfactory.

In deciding to adopt homogenization before pasteurization as standard practice with the introduction of the vacreation method, it was felt that this departure would reduce the chances for contamination subsequent to pasteurization.
CONDENSING MILK WITH THE VACREATOR

This is the latest reported use of the Vacreator in the dairy field.

A member of the Oregon Agricultural Experiment Station staff in 1939 had considered the possibility of condensing milk for ice cream mix with the Vacreator. With the United States active participation in World War II and the lend-lease plan in effect, there developed a scarcity of spray process nonfat dry milk solids. This product had been in general use for increasing the amount of milk solids-not-fat in ice cream mix. As difficulty was experienced in obtaining sufficient dry milk for ice cream mix, it was decided to activate an experimental project on condensing milk, or ice cream mix, by means of the Vacreator.

The use of the Vacreator not as an apparatus for high-temperature, short-time pasteurization, as previously outlined, but as a condensing unit involved a number of problems. Simply circulating milk or mix through the machine and operating it with steam, as a vacuum pasteurizer, did not result in any material alteration of the composition of the milk or mix. It was necessary to evolve a different and considerably modified treatment. The machine had not been used for this purpose before.

For the satisfactory condensing of milk or mix by the Vacreator it was necessary to postulate the following:

1. Condensing process must not cause an undesirable caramelized cooked, or scorched flavor in the product.
2. The physical condition of the condensed product must be satisfactory. No undesirable curdling must take place.
3. The length of time required for condensing must not be excessive.
4. The amount of steam, water, and power must not be so large that the cost becomes excessive.
5. The process should be semiautomatic so the cost of supervision during condensing is not excessive.
6. A dependable, simple method of determining when the condensing process is completed must be provided.

After about one year of experimentation a simple, practical, and inexpensive method of condensing milk to the concentration desired for ice cream mix, using the Vacreator without any mechanical change as a milk condenser, was devised. Condensed milk of a highly satisfactory quality was obtained.
The method of condensing is as follows:

1. Place the necessary amount of skim milk in a tank.
2. Pump the milk through a continuous preheater and heat it to 200° - 205°.
3. Allow the hot milk to enter the first chamber through the float valve.
4. With the equilibrium valve removed maintain a vacuum of 24 to 25 inches in the second chamber and a vacuum of 27½ to 28 inches in the third chamber. Use no steam.
5. Continuously return the condensed milk to the supply tank.
6. Continue to circulate the milk through the Vacreator until the milk in the tank is of the desired concentration.

With a rate of flow of milk of 5,000 pounds per hour approximately 500 pounds of water can be removed per hour with the Baby Size Vacreator.

With a rate of flow of milk of 12,000 pounds per hour approximately 900 to 1,000 pounds of water can be removed per hour with the Junior Vacreator.

The condensed milk will have a fine flavor, free from any cooked character. The milk will leave the Vacreator at a temperature of approximately 110° F. About 45 minutes condensing with the Baby Size Vacreator were required to remove sufficient water from the milk to result in a condensed product of the proper density for a 900 lb. ice cream mix of standard composition. Immediately after condensing, the cream, sugar, gelatin, etc., are added to the condensed milk and the complete mix can then be homogenized, vacreated and cooled.

Whole milk can also be satisfactorily condensed but sufficient data from research on this is not available.

The complete milk-cream-sugar-gelatin-mixture can also be condensed, but it is considered more practical to first condense the milk.

In the tests made in Oregon and also in a commercial ice cream factory in Pennsylvania, ice cream of an excellent quality was obtained from vacreated ice cream mix with which vacreated-condensed milk was used. The cost of condensing milk by this method was found to be reasonable.

Condensing milk with the Vacreator may find considerable application in ice cream factories that do not have a vacuum pan. The Vacreator can be used for the dual purpose of condensing milk and vacreating ice cream mix.

Additional experiments involving the use of the Vacreator for condensing buttermilk, whey, chocolate milk and for removing water from other dairy products are contemplated.
REFERENCES

1. G. H. Wilster, Vacuum Pasteurization of Cream for Butter, Oregon Agricultural Station Bulletin 368, 1940.

2. N. E. Fabricius and E. W. Bird, The Quality of Butter Made from Vacuum-Pasteurized and Vat-Pasteurized lots of the Same Creams, Iowa Agricultural Experiment Station Research Bulletin 234, 1940.


7. G. H. Wilster, The Dual Use of the Vaecretor for Condensing Milk and Pasteurizing Ice Cream Mix, Oregon Agricultural Experiment Station Bulletin 430, 1945.
CONTROL OF THE QUALITY AND COMPOSITION OF BUTTER

Normally about 1\(\frac{2}{3}\) billion pounds butter are manufactured annually in the creameries in the United States. Next to fluid milk and cream, butter accounts for a greater amount of milk fat than all other manufactured dairy products combined. This is seen from the following data for the pre-war year of 1940 as reported by the United States Department of Agriculture.

Consumption of Butterfat Per Person for Year 1940

<table>
<thead>
<tr>
<th>Product</th>
<th>Butterfat Per Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid milk and cream</td>
<td>14.20 pounds</td>
</tr>
<tr>
<td>Butter</td>
<td>13.40 &quot;</td>
</tr>
<tr>
<td>Cheese</td>
<td>1.92 &quot;</td>
</tr>
<tr>
<td>Evaporated milk</td>
<td>1.33 &quot;</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>1.38 &quot;</td>
</tr>
<tr>
<td>Condensed, dry whole, and malted milk</td>
<td>0.11 &quot;</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32.39 pounds</strong></td>
</tr>
</tbody>
</table>

We sometimes wonder if any progress has been made in improving the quality and composition of butter through improved butter-making methods and by the use of butter equipment during the time most of us have been engaged in this industry. I think that remarkable progress has been made. I should like to briefly enumerate some of the factors in the improvement.

1. The use of chrome-nickel steel alloys for surfaces of pasteurizers, vats, pipes, fittings, cooler, etc., with which milk and cream come into contact in the creameries.

2. Elimination of iron cream pumps and the use of sanitary pumps constructed from non-corrosive metal and equipped with sanitary rotary seal in place of stuffing boxes.

3. Provision for a separate pump for buttermilk.

4. Adoption of flush valves for pasteurizing vats and storage tanks.

5. Installation of recording thermometers on cream pasteurizers.

6. Improved, more exact methods of neutralization.

7. Prevention of oily-fishy flavor development in butter through control of the manufacturing process and avoidance of contamination of the cream and butter with copper and iron.

8. Controlled methods of preparing and using starter when such is used.
9. Introduction of roll-less churns and all-metal churns.
10. Development of metal butter tampers, ladles, and strikers.
11. Improved treatment of parchment paper.
13. Adoption of methods of cleaning and sterilizing equipment to prevent the development of putrid, and other bacteria-induced flavors, during the storage of butter.
15. Improved workmanship and processing technique to control leakiness of butter.

But butter has been "knocked about" during the last several years. Not only has the quantity manufactured greatly decreased but the quality has suffered considerably. Now is the time for a vigorous quality improvement program. We should intensify our research relating to butter. Americans like fine-quality butter and will eat generous amounts of it if it has a good flavor and possesses a fine waxy body so that it spreads well on bread or on rolls.

In the overall improvement in butter quality it is necessary that the improvement in the production and assembling of the milk and cream goes hand in hand with improved application in the manufacturing plant.

The factors that enter into the quality of butter are:

- Flavor
- Body and texture
- Color
- Salt
- Appearance, package
- Freedom from extraneous matter, molds, yeasts, undesirable bacteria, copper and iron.

The present discussion deals with the methods the buttermaker has in controlling the quality of butter.

The flavor. This is the most important of the factors which make up quality. In the score card for butter 45 points are allotted for flavor.

The flavor of fine butter may be characterized as clean and delicate, fresh, mildly salty, mellow. There must be no taint present from feed, weed, old cream, dirty utensils, from fermentation due to
undesirable microorganisms, or from enzymatic or other chemical action.

The buttermaker has no direct control over the methods of producing and handling the milk and cream on the farm. But he should be familiar with the causes on the producing farms of certain undesirable flavors in order that the creamery field man or the creamery manager may advise the producer to use corrective measures in order to control the defects. Speedy pickup of cream from the farms and early arrival of the cream at the creamery are aids in preserving the good flavor of milk and cream. Shady roadside stands and closed trucks are desirable.

All supplies of milk and cream should be graded on their arrival at the creamery. If milk or sweet cream are received, the grader must place into a second grade any milk or cream that has a pronounced feed or weed flavor, an unclean flavor, an acid flavor, or a slight rancid flavor. Milk or cream which is dirty, and cream which is yeasty, pronouncedly rancid, cheesy, moldy, metallic, tallowy, stale etc., should be returned to the producer. If sour cream is being received, any cream which is only mildly sour but is not stale may be placed in the top grade and good flavored medium, or high acid, cream may be placed in the next lower grade, while definitely off-flavored cream should either be returned to the producer or sold to some creamery that can make churnings of second grade or cooking grade.

There is no known method that the buttermaker can use for eliminating stale, metallic, rancid, yeasty, and similar off flavors from cream.

When sour cream is received it is necessary to reduce the acidity by neutralization with an alkali. The control of the acidity of the cream is very important, especially if the butter is to be stored for some time. The acidity should be adjusted to such a point that the serum of the butter will have a pH of from 6.7 to 7.0. For long-time storage the neutral point is preferable. A high acidity (low pH) favors the development of oily-fishy flavor. Over-neutralization must be avoided.

Correct pasteurization is one of the important steps in controlling butter quality. The temperature and time of exposure should be such that all pathogenic bacteria and all yeasts and molds are destroyed. The enzymes should be inactivated. A high percentage of the non-pathogenic bacteria should be killed. Contamination with microorganisms from air, equipment, and water after pasteurization must be avoided and the pasteurized cream should be protected from light and metals such as copper and iron.
The expulsion of flavors imparted to cream by feeds and weeds consumed by the cow, and certain loosely bound extraneous flavors, may be accomplished by using a vacuum method of pasteurization.

Some markets prefer butter that has a flavor that is more pronounced than is obtained when sweet cream, or cream that has been neutralized, is churned. The addition of a small amount, 3 to 5 percent, of fine-flavored starter, may be added to the cream, either just before churning, or several hours before, without ripening to increase the acidity. The addition of starter to cream of low quality is of doubtful value. The addition of artificial flavoring compounds is prohibited by regulatory agencies.

Body and Texture. Well-made butter possesses a waxy characteristic and a close, well-knit texture. This is much appreciated by the consumers. When at the proper temperature for spreading, butter can be spread evenly on bread without crumbling.

The buttermaker has in his control the manufacture of butter that possesses a desirable spreading property and that is neither greasy nor leaky.

Proper control of the body and texture of butter consists of:

1. Cooling the cream to 40°F. during spring and summer and not below 50°F. during winter.
2. The churn in a good physical condition.
3. Not overfilling or greatly underfilling the churn.
4. The cream in the churn of the correct temperature for churning in the time required for exhaustive churning and to give a firm-bodied butter.
5. Washing with water of a temperature to properly chill the butter granules.
6. Thorough distribution of the salt.
7. Working the butter until the brine droplets are uniformly incorporated and thoroughly subdivided but not so much that the butter becomes either saivy or sticky.

The buttermaker who is able to manufacture butter that has a fine waxy body and a close texture is indeed an artist. He should strive to make every churning of butter superior in body and texture.
Color. It is sometimes overlooked that color is rated 15 of the 100 points on the score card. The attractive golden-yellow color of butter is much appreciated by the consumers. It is very fortunate that nature has given milk fat a color which is so pleasing to the eye. No other color would be as attractive.

The shade of yellow color varies with the kind of feed eaten by the cow. When green feed is eaten, the color of the fat is deeper than when dry feed is consumed. Consumers prefer butter which has a uniform color throughout the year. The color of butter is satisfactory during spring, summer and early fall, but during the balance of the year a small amount of color must be added to the cream in order to maintain the desirable shade of yellow.

The butter must have a good lustre. A "lifeless" dull color is not wanted. The color should be uniform. There must be no streaks or mottles.

Salt. Most Americans prefer salted butter. About 2½ percent is considered best on the Pacific Coast. The salt must be all dissolved. If the brine is finely incorporated the butter will be free from a harsh, briny taste. Clean salt, free from an undesirable bitter taste, should be used.

Package and Finish. The butter prints must be neat, and even, free from holes and fingermarks.

Control of Extraneous Matter, Yeasts and Molds. Modern operations practically guarantee that the butter is free from undesirable extraneous matter and from yeasts and molds. If the equipment is in a first-class condition, if filtered water is used, if clean salt is added to the butter, if the creamery is free from flies and other insects, and if the atmosphere is kept reasonably free from soot and dust (preferably air conditioned and the incoming air filtered) the butter will be free from objectionable extraneous matter. Yeasts and molds can be controlled by (1) efficient pasteurization, (2) the use of clean, sterilized pipe lines and fittings, pumps, strainers, churns, butter packing equipment and molds and (3) using water that is free from these organisms. The finished butter must be protected from contamination and must be printed with clean sterilized equipment. Mold-free parchment paper should be used for wrapping.

Control of Composition. A modern butter manufacturing operation has sufficient control so that every churning of butter shows practically no deviation from the desired composition. A "must" is that every churning contains at least 80 percent fat as required by law. No creamery can afford to jeopardize its reputation by manufacturing butter that contains less than the legal amount of fat.
Every creamery should have equipment for analyzing butter for fat, moisture and salt. The finished butter in each churning should be analyzed and a record made of the results. The maximum deviation from the standard in the fat content should not exceed 0.3 in the percentage. A standard for fat may be 80.3 per cent in a creamery that has good composition control. If the standard for salt is 2 per cent, a maximum deviation in the percentage should not exceed 0.1

A sample of butter from each churning should also be used for a two-week keeping quality test and for an examination for extraneous matter.

The following is an outline of the method of controlling the composition of butter:

1. Accurately determine the pounds of cream in each churning. Also, weigh the trimmings if these are to be added to the cream.

2. Determine the fat percentage of the cream in the vat and compute the pounds fat present.

3. Compute the amount of butter that should be obtained.

Example:

1000 pounds fat available
1 per cent of fat lost in buttermilk
1/3 lb. fat lost through foam and dripping
989.5 lbs. fat for butter

\[
\frac{989.5 \times 100}{80.5} = 1229 \text{ lbs. butter containing } 80.5 \text{ per cent fat.}
\]

\[
\frac{229 \times 100}{1000} = 22.9 \text{ per cent over-run}
\]

A table has been prepared by the author that shows (1) the pounds of fat in different lots of cream varying from 500 to 5000 pounds, with fat contents ranging from 29 to 42 per cent, (2) the pounds of butter that can be obtained (22.9 per cent over-run), and (3) the pounds of salt that must be added to the butter in each churning in order that the finished butter will contain 2.3 per cent salt. It is considered that the composition of the finished butter is 16.5 per cent moisture, 80.5 per cent fat, 2.3 per cent salt, and 0.7 per cent curd.

4. When the salt is added, also add some water, enough to give nearly the desired amount of moisture in the butter.
5. Work the butter until it is almost dry.

6. By means of a spatula, remove a representative sample of the butter from the churn for a moisture determination. Test for moisture.

7. Calculate the amount of water to add to the butter in order to obtain butter of the desired moisture content. Add filtered water of the same temperature as the butter.

A table has been prepared by the author that shows the pounds of water to add to churnings of unfinished butter, when the fat in the cream before churning varies from 300 to 2,000 pounds and the moisture in the unfinished butter at the time of making the first moisture test varies from 15.5 to 16.4 per cent.

The amounts of water have been calculated from the application of an algebraic formula.

8. Work the butter until the added water has been thoroughly incorporated. The butter should be thoroughly worked so that the moisture droplets are finely divided. Unless this is done, the butter will leak during and subsequent to printing.

9. Finally, analyze the butter for total composition: moisture, fat, salt, and curd.

OREGON BUTTER IMPROVEMENT PROGRAM

The consumption of dairy products in Oregon about balanced production during 1917 to 1919. By 1920 there was an excess of about 2 million pounds fat. The surplus dairy products, mainly butter and cheese, were sold on out-of-state markets. Increasing amounts of surplus butter and cheese became available each year following 1920.

Improvement of butter quality and composition became a "must" in Oregon during the late twenties. The 104 creameries manufactured 25 million pounds butter during 1929 of which 20 million pounds were sold in the state and the remainder in California and Washington. Complaints of low quality, irregular composition and of poor keeping property reached agricultural leaders.

A survey of the marketing problems of Oregon creameries, including a study of the underlying causes of poor butter, was made in 1926 by the Oregon Agricultural Experiment Station. Practically every creamery in the state was visited by the investigators. The markets of Los Angeles, San Francisco, Seattle, and Spokane were studied.
Nearly all jobbers and wholesalers in Portland were interviewed.

Mid-20's Study Summarized

In the survey summary it was stated, "Practically every creamery in the state is confronted with acute marketing problems. Each creamery is attempting to sell its own products independently of the others; therefore, there are about as many competitors as there are creameries in operation. Even with so large a number of creameries there is a greater uniformity in the method of marketing than would ordinarily be expected.

"The most serious difficulty is with the quality of the product which they have to market, since there is a wide variation in its quality. Butter scoring from 83 to 95 points is being offered for sale in various markets of the state and the common criticism of the wholesalers and jobbers in the largest central market in the state, Portland, was that the butter sent them by the various creameries varied so much in the quality and quantity, one shipment with another, that it was practically impossible to build up any regular trade on the product received from the different creameries.

"As a consequence it was necessary for them to determine the quality of each lot of butter received and try to dispose of it to a particular trade that required that grade of butter. Thus a consumer could get the butter from a certain creamery one time and possibly from another the next. The better way, of course, would be for the creameries to furnish a uniform quality regularly, thus making it possible to build up a regular trade with the consumers."

A scoring of 56 samples of commercial butter collected during 1926 showed that the quality was as follows:

<table>
<thead>
<tr>
<th>Percentage of all samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>92 score and above</td>
</tr>
<tr>
<td>91 to 92 score</td>
</tr>
<tr>
<td>90 to 91 score</td>
</tr>
<tr>
<td>83 to 90 score</td>
</tr>
</tbody>
</table>

In the summary report, it was also stated that: "The trend of the consumer demand is for higher quality butter. The increasing demand for better quality butter is recognized by most creameries.

"The future success of Oregon's dairy industry depends upon united action within the industry in improving the quality of butter and the correction and elimination of present evils existing in the purchase of raw materials and group action in the marketing of the manufactured product."
Later Study of Butter Quality

A detailed study of the conditions in the butter industry in the state was made by the Oregon Agricultural Experiment Station in 1928-1929. In the field study where detailed observations of the quality of cream received, cream grading, methods of manufacturing, and other factors were made, it was found that a considerable variation existed in the quality of the cream received at the different creameries. Cream quality was influenced more by the attitude of the creamery management than by reason of any regional, climatic, or other conditions. There was intense competition for cream among the different creameries in the state. With no compulsory system of paying for cream in accordance with quality, the competition resulted in a sacrifice of quality in order to maintain volume.

In nearly every plant visited, some undesirable practices were noticed. The most common of these were the lack of proper grading of the cream before churning and failure to keep out the old and off-flavored cream for churning separately. It was customary for the buttermakers in many of the plants to include with the regular churning the poorer lots of cream received in the hope that the defective flavor would be concealed. Incorrect methods of neutralizing and pasteurizing cream were common. Ordinary cheap glass thermometers were used by most plants. Yeast and mold control was inadequate.

With such conditions, it is not surprising that an undesirable flavor developed in some of the butter during its trip from the creamery to the consumer's table. Some of the complaints received from out-of-state markets can be explained partly by the presence in the butter at the time of manufacture of an excessive number of undesirable microorganisms.

A grading of 104 samples of commercial butter during the winter 1928-1929 showed scores that ranged from 87 to 93. Only 9.6 per cent of the samples scored 92 to 93, while 21.2 per cent scored less than 90.

Quality and Composition Program Started

Because of the great variation in the quality of the butter made and the small quantity of high-scoring butter found on the market, the Oregon Agricultural Experiment Station, in March 1929, started a free monthly butter-scoring and analysis service. It was thought that such a project would help to improve its marketability. The plan for the service was perfected during a meeting at Portland in February 1929. Those present were H. C. Raven, R. E. Cavett, commercial creamery operators; L. B. Ziemer, Deputy Dairy and Food Commissioner; and G. H. Wilster, Oregon State College.
This service was offered to all creameries and the first year was taken advantage of by 60 different plants. The number using this service increased gradually until about three-fourths of the state's 95 creameries took advantage of the service. In view of the public-service character of the work, no research or other special legislative funds were used for defraying the cost.

Each of the participating creameries has mailed two one-pound prints of butter from its regular first grade churnings on the second Monday of each month. One of the pound prints has been scored when fresh—about one week old—and the other has been used for a keeping quality test. Before scoring each print has been rewrapped in plain parchment paper and given a number for identification. The work of scoring has been done by a group of competent butter judges consisting of Federal and State officials and commercial men, usually in the dairy building at Oregon State College.

Survey Kept Confidential

The work has been kept confidential. The judges have had no knowledge of whose butter they were scoring. In addition to the scoring, a determination of the amount of fat, moisture, salt, and curd, and the number of yeasts and molds present, has been made. During later years, a determination of the pH value was included. From the results obtained, an efficiency score for each sample has been calculated.

Samples from approximately 7500 churnings have been scored and analyzed and rescored after the keeping quality period. Monthly summary reports have been sent to the participating creameries. Suggestions for improvement in quality and composition of the butter have been made. Methods for controlling yeasts and molds have been outlined. Numerous "Timely Topics" of interest to buttermakers have been discussed. A manual was published. Important meetings have been held in various parts of the state. Complaints from markets are now rare. The following comparison shows the improvement that has taken place in the quality during the 13 years of the improvement work.

<table>
<thead>
<tr>
<th>Score</th>
<th>1929-30 1st Year</th>
<th>1941-42 13th Year</th>
<th>Change 13th Year Compared with 1st Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>92 and above</td>
<td>435 Churnings</td>
<td>621 Churnings</td>
<td>+ 51.3 (increase)</td>
</tr>
<tr>
<td>91</td>
<td>7.8%</td>
<td>35.6%</td>
<td>+ 2.5 (increase)</td>
</tr>
<tr>
<td>90</td>
<td>33.1%</td>
<td>4.2%</td>
<td>-54.4 (decrease)</td>
</tr>
<tr>
<td>Below 90</td>
<td>20.5%</td>
<td>1.1%</td>
<td>-19.4 (decrease)</td>
</tr>
</tbody>
</table>
The economic importance of making high-grade butter is recognized. The difference between the average yearly wholesale price of 92 and 90 score butter at San Francisco for 1941 was 1.79 cents. On 32,000,000 pounds butter (Oregon's production for that year), this would be a difference of $572,800.00 or over one-half million dollars.

The demand is for butter that possesses the following characteristics:

1. Fine flavor and aroma, uniform throughout the year.
2. A good body and texture. Good spreadability. Must not lose brine when printed.
3. A medium salt content, the salt uniformly incorporated.
4. An attractive color of uniform shade during all seasons.
5. A fat content that meets the legal requirements.
6. A good keeping quality. A fishy, rancid, or putrid flavor must not develop.
7. Made from efficiently pasteurized cream in a sanitary creamery so the butter does not become moldy.
8. Completely free from extraneous matter such as hair, dirt, etc.

Color Made More Uniform

Consumers are sensitive to a change in the color of butter. They demand that it be kept uniform from day to day throughout the year. It is, therefore, necessary for the buttermakers to standardize the color of the butter they are marketing. All samples of butter received have been graded for color since the fifth year of the scorings. Chr. Hansen's Standard color-comparison cards have been sold.

Whereas during the fifth year only 62.3 per cent of the samples were of the preferred shade; during the 13th year 96.6 per cent were of this shade of yellow color.

Improvement in Composition

Marked improvement has taken place in composition as will be seen from the data herewith. During the first year of the work, only 56.9 per cent contained 80 to 81 percent fat with 15.6 per cent below 80 per cent fat. During the 13th year, 82.2 per cent contained 80 to 81 per cent fat and only 3.5 fell below the legal standard of 80 per cent fat.

If a creamery makes 1,000,000 pounds of butter in one year and the butter contains 1 per cent fat in excess of the normal, it loses the value of 10,000 pounds fat. If this fat is worth 50 cents a pound, the loss sustained is $5,000.
## Change in the Fat Content of Butter Analyzed

<table>
<thead>
<tr>
<th>Per Cent of Fat</th>
<th>1929-30 1st Year</th>
<th>1941-42 13th Year</th>
<th>Change 13th Year Compared with 1st Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 80</td>
<td>15.6%</td>
<td>3.5%</td>
<td>-12.1% (decrease)</td>
</tr>
<tr>
<td>80.0 to 81.0</td>
<td>56.9%</td>
<td>82.2%</td>
<td>25.3% (increase)</td>
</tr>
<tr>
<td>31.1 and above</td>
<td>27.5%</td>
<td>14.3%</td>
<td>-13.2% (decrease)</td>
</tr>
</tbody>
</table>

### Salt Content Reduced

Consumers prefer light-salted butter. About 2.2 to 2.3 per cent seems to be ideal. This percentage was decided upon by the creamery industry in 1931 when the single standard for composition of butter (min. 80 per cent fat) was adopted. The data in the accompanying table very strikingly show the effectiveness of the program to reduce the salt content to meet market requirements. Scores were undoubtedly increased by lowering the salt content. During the 13th year, 96.8 per cent of the samples contained less than 2.6 per cent salt and the average salt percentage of all the samples was 2.2 per cent.

## Change in the Salt Content of the Samples Analyzed

<table>
<thead>
<tr>
<th>Per Cent of Salt</th>
<th>1929-30 1st Year</th>
<th>1941-42 13th Year</th>
<th>Change 13th Year Compared with 1st Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 2.6</td>
<td>28.5%</td>
<td>56.8%</td>
<td>28.3% (increase)</td>
</tr>
<tr>
<td>2.6 to 3.0</td>
<td>48.7%</td>
<td>3.2%</td>
<td>-45.5% (decrease)</td>
</tr>
<tr>
<td>3.1 and above</td>
<td>22.8%</td>
<td>0%</td>
<td>-22.8% (decrease)</td>
</tr>
</tbody>
</table>

### Yeasts and Molds in Butter

The yeast and mold content of the fresh samples of butter is, to a large extent, an indication of the efficiency of pasteurization of the cream and of the efficiency in the cleaning and the sterilizing of the buttermaking equipment. The yeast and mold counts were high during the first several years. Some improvement has been effected, but too many of the churnings of butter during the 13th year contained an excessive number of these organisms. Butter should be free from yeasts and molds. Moldy butter on the market means not only a total loss of the particular lot, but a more serious loss due to buyer resistance to further purchase of butter from the same source.
CHANGE IN THE YEAST AND MOLD COUNTS OF THE SAMPLES ANALYZED

<table>
<thead>
<tr>
<th>Y &amp; M</th>
<th>1930-31</th>
<th>1941-42</th>
<th>Change 13th Year Compared with 2nd Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cc.</td>
<td>2nd Year</td>
<td>13th Year</td>
<td></td>
</tr>
<tr>
<td>of Melted Butter</td>
<td>Percentage of All Samples</td>
<td>Percentage of All Samples</td>
<td></td>
</tr>
<tr>
<td>Less than 10</td>
<td>5.1</td>
<td>13.6</td>
<td>8.5</td>
</tr>
<tr>
<td>10 to 100</td>
<td>30.1</td>
<td>28.6</td>
<td>-1.5</td>
</tr>
<tr>
<td>101 to 1,000</td>
<td>47.3</td>
<td>30.8</td>
<td>-16.5</td>
</tr>
<tr>
<td>More than 1,000</td>
<td>17.5</td>
<td>27.0</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Summary of Improvement and Standardization Work

1. The flavor and body and texture of the butter made in the majority of Oregon's creameries have shown substantial improvement.

2. Through better methods of manufacture, the keeping quality of the butter has been improved.

3. The color of the butter has been made more uniform.

4. A higher percentage of the butter during the 13th year contained the ideal percentage of fat than was the case during the first year.

5. The salt content of the butter has been reduced to suit market requirements.

6. The general quality of the butter has been made more uniform and more suitable for shipment to out-of-state markets.

7. The market value of the butter made has been greatly increased.

Compulsory Milk and Cream Grading

An important step in Oregon's program of improving and standardizing the quality of the butter manufactured was the establishing of uniform grades for milk and cream and making it compulsory for the creameries to pay for these products in accordance with the grade. The law provides for the licensing of graders and for the return to the producer of milk or cream which is unfit for human consumption. The State Department of Agriculture was given authority to enforce the law. Each creamery must employ at least one grader.
Licensing Buttermakers

Another step in Oregon's butter improvement program was the enactment by the State Legislature in 1939 of a law that provides for the licensing by the State Department of Agriculture of all buttermakers in the creameries. Each buttermaker must pass a written and an oral examination before he can obtain a license. One year's experience in a creamery is a prerequisite for obtaining a license.

THE VACREATION OF CREAM FOR BUTTER MAKING

Introduction of Pasteurization

It was in 1897 when H. E. Schuknecht in the Farmers Cooperative Creamery, Albert Lea, Minnesota, first used the method of pasteurizing cream for butter manufacture. He found that this new process resulted in butter that possessed a greater uniformity in flavor and had a better keeping quality as compared with butter made from unpasteurized cream. Mr. Schuknecht found a market in Europe for this new type of butter. Today there is probably not a single creamery of the some 4,000 plants in the United States that is not pasteurizing the cream before it is used for butter.

Development of Vacreation

In New Zealand, a country that is well known for the advanced state of development of its dairy industry and for the high quality of the butter and cheese manufactured, was recently developed a new method of pasteurization which is known as "Vacreation." The inventor is H. Lamont Murray, who with Frank S. Board perfected this vacuum method of pasteurization. A pasteurizer known as a "Vacreator" was designed.

When Murray was operating a condensed milk factory in the Waikato district, Auckland Province, New Zealand, he observed that feed flavor, which was common in the milk, was largely eliminated during the condensing process. He later reasoned that if these volatile flavors could be removed from milk while boiling at reduced pressure without any deleterious effect on the natural flavor or other properties of the milk, a similar method might be employed in the treatment of cream used in buttermaking. Flavors in milk and cream arising from turnips, clovers, spring grass, and various weeds, consumed by the cows, were common. In 1923 Murray and Board while operators of the Te Aroha Dairy Company, Ltd., which had an annual output of 4 to 5 million pounds of butter, set out to apply this principle to the treatment of cream.
Influence of Vaoreation on the Quality of Butter

1. Tests at the Oregon Agricultural Experiment Station

The investigation extended over one year. In a series of 86 comparisons involving 200 gallon-lots, cream of good quality was divided into equal parts. One part was pasteurized by the usual coil vat method (155 deg. F. for 30 minutes) and the other was vacreated. Additional lots of weed-flavored cream and cream of variable quality were also used. The butter was graded weekly by a committee of three or four men. The samples were known by number only and the numbering system was such that the judges obtained no clue through the use even or uneven numbers or of consecutive numbering regarding the method of pasteurization.

For the 86 comparisons the vacreated-cream butter scored highest 71 times. The average score of the butter from vacreated cream was 92.38 and the average score of that from the vat-pasteurized cream was 91.55. Thus vacreation resulted in increasing the average score 0.83 point. This represents a very remarkable improvement when it is considered that the difference in score between mediocre quality butter and the finest commercial butter is only three points, 93 score being the top commercial grade.

The greatest improvement took place during the spring months. This was due, primarily, to the freeing of feed, weed, and certain loosely bound extraneous flavors from the cream during vacreation.

Butter in 33 comparisons was shipped in 68-pound boxes to Portland for scoring by the Federal butter grader stationed there. Of the butter from vat-pasteurized cream 10 lots scored 92-93 whereas of the butter from vacreated cream 25 lots scored 92-93.

When butter in 79 comparisons was stored at a temperature of 0 to 10 deg. F. for four months, there was a difference of 0.78 point in favor of the average score of the butter made from vacreated cream.

The vaoreation method was found to be more efficient in killing bacteria than the vat pasteurization method. In 35 comparisons the geometric average number of bacteria per ml. in the vat-pasteurized cream was 9,284 and in the vacreated cream it was 495.

When cream badly tainted with onion, or with French weed, was used in the experiments the vat method was not effective in removing the undesirable flavor but the vacreation method was effective.

Since these tests were made all butter manufactured in the Oregon State College Dairy Products Laboratory has been made from vacreated cream.
2. Tests at the University of Manitoba

It was reported that of 153 direct comparisons made in the study between butter made from vat pasteurized and vacreated cream, all but 8, or 145, were in favor of the butter made from vacreated cream on the basis of the flavor scores.

3. Tests Made at the Iowa Agricultural Experiment Station.

The results showed that vacreation of good quality cream gave butter of significantly higher score than vat pasteurization of portions of the same cream. There was an average difference of 0.97 point in the score in favor of the butter made from the vacreated cream. Butter made from fine quality vacreated cream was sent to ten different state and national butter contests. The scores ranged from 93 to 95 points. Although the cream was vacuum pasteurized at a temperature of 190° to 200° F. in the vacreator no undesirable heated or cooked flavor was present in the butter.

REFERENCES


2. Fabricius, N. E. and Bird, E. W., The Quality of Butter Made from Vacuum-Pasteurized and Vat-Pasteurized Lots of the Same Cream. Iowa Agriculture Experiment Station Bulletin 284, 1940.


CONDITIONS IN AND THE FUTURE OF THE DAIRY INDUSTRY IN THE NORTHWEST
AS IT AFFECTS THE REMAINDER OF THE COUNTRY

The three Pacific Northwest states -- Washington, Idaho, and Oregon, cover an area of 1/4 million square miles. This area is 41⁄2 times larger than the state of Illinois. Prewar population in the three states was only 3-1/3 million compared with Illinois’ 8 million. It is a section of considerable natural wealth. Important industries are lumbering, cattle and sheep raising, wheat growing, dairying, fruit and vegetable growing, mining, fishing, while tourists are a source of considerable income.

The three states have had a surplus of dairy products. California markets have been the natural outlet for them. Of 88 million pounds of butter received at San Francisco and Los Angeles during 1945, Idaho supplied 20 million, Washington 1 million, and Oregon 32 million. The four states -- Illinois, Iowa, Minnesota, Nebraska -- sold 26 million pounds during that year on these two markets.

Of 34 million pounds cheese received on the two markets, Idaho furnished 5 million pounds, Oregon 5 million pounds and Washington 200 thousand pounds. Wisconsin furnished 9 million and Illinois 2 million pounds.

In addition to butter and cheese, considerable amounts of dry milk, evaporated milk and dry whey manufactured in the Northwest have been regularly sold in California.

With the location of shipyards, war industry plants, and army and navy camps in the Northwest, much milk has been diverted to the fluid milk trade and to ice cream plants during the last several years. The production of butter, particularly, has been greatly curtailed. In prewar years, Oregon shipped 25 million pounds total butter and cheese to California.

A large area of the Pacific Northwest consists of timber and grazing land. The numerous mountain ranges are covered with dense forest to timberline of about 6000 feet elevation. Agriculture in the area is perhaps more diversified than in any other similar area in the United States. The climate, precipitation, soil, and elevations are quite different in sections of this area. Whereas in Western Washington and Oregon the rainfall and climate favor green feeds throughout the greater part of the year, on the plateaus of Eastern Oregon and Washington dry farming is practiced, and in the valleys of these states as well as in Idaho irrigation of crop land and pastures is common.

The dairy industry is an important part of agriculture in the three states. As the states have a surplus agricultural production, economists have encouraged the production of concentrated products,
such as dairy products, for shipment to out-of-state markets.

Let me discuss in a little detail the dairy conditions in Oregon as I am most familiar with them.

Of the 62,000 farms in Oregon, 85% are privately owned. Irrigation is practiced on 10,000 farms. The farms occupy only 29 per cent of the total land area. The balance consists of forest land and range grazing land.

The dairy industry is the largest single item source of cash farm income in the state, accounting for about one-sixth of the total cash farm income. In 1943, the farmers received 40 million dollars for their milk. The 300,000 cows produced in 1944, 1\frac{1}{2} billion pounds milk. This is small when compared with the 5\frac{1}{2} billion pounds produced in Illinois that year.

The production of major dairy products in Oregon during 1944 were:

<table>
<thead>
<tr>
<th>Product</th>
<th>Production (lbs.)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>24,000,000</td>
<td>(Down 8 million from prewar)</td>
</tr>
<tr>
<td>Cheese</td>
<td>27,000,000</td>
<td>(Up 6 million from prewar)</td>
</tr>
<tr>
<td>Cottage Cheese</td>
<td>2,000,000</td>
<td></td>
</tr>
<tr>
<td>Evaporated milk</td>
<td>42,000,000</td>
<td></td>
</tr>
<tr>
<td>Non-fat dry milk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>solids</td>
<td>9,000,000</td>
<td></td>
</tr>
<tr>
<td>Dry whole milk</td>
<td>5,500,000</td>
<td>(Nothing before the war)</td>
</tr>
<tr>
<td>Dry whey</td>
<td>11,000,000</td>
<td></td>
</tr>
<tr>
<td>Ice Cream</td>
<td>4,000,000</td>
<td>(Up to 1 million from prewar)</td>
</tr>
</tbody>
</table>

The dairy cattle in Oregon are predominantly Jersey. About 80 per cent of the total are of the Jersey breed. The average fat content of the milk produced is 4.4. More world records have been produced by Oregon Jerseys than by any other state. But Oregon has representation in the top production records and honors in all of the five leading dairy breeds. In the butterfat production for the five highest records for each age and class of records, Oregon holds 48 of a possible 725 such records. Of the 48 records, 38 are Jerseys. Oregon holds 16 of the country's 576 one-thousand-and-above pound fat producers, 13 of which are Jerseys. Oregon holds one 20-thousand pound milk producer in the Brown Swiss breed and eight 30-thousand pound milk producers among the Holsteins.

Butterfat production per cow in Oregon has materially increased since a vigorous state-wide planned program of better sires, production testing, better feeding, pasture improvement, and dairy management, was inaugurated in 1924, following a general agricultural conference. In 1924, the average production of milk fat per cow in Oregon was only 168 pounds. For 1943, the average production was 249 pounds, an increase of 31 pounds or 48 per cent - a most notable achievement. The
average production per cow in the United States during 1943 was only 133 pounds. The Oregon average for 1943 was equalled by New Jersey and exceeded only by California with a production per cow of 256 pounds.

The state of Oregon has an area of 96,000 square miles. It extends from the Columbia River on the north 250 miles to the California border on the south, and from the Pacific Coast on the west 400 miles to Idaho on the east. The Cascade range of mountains of an average elevation of 8 to 10,000 feet, extends through the state from the north to the south. The Blue Mountains and the Wallowa Mountains in northeastern Oregon (America’s Switzerland) have an elevation ranging from 5,000 to 10,000 feet.

The elevation of towns located in various parts of the state vary from 9 feet for Coos Bay, located on the coast, to 4,148 feet for Burns, located in the central part of the state.

Precipitation varies greatly throughout the state. On the coast it ranges from 60 to 95 inches per year. This is a very fine dairy section. The winters are mild and summers cool. Grass is abundant. Oregon’s cheese industry is located in this section.

The rainfall in the Willamette and Umpqua Valleys located between the coast range of mountains and the Cascade Mountains averages 40 inches per year. But the precipitation is poorly distributed throughout the year. The three summer months are practically devoid of rain. Flood control is necessary during the winter and irrigation is required during the summer for pastures, for gardens, and for truck crops. The climate is mild, snow is uncommon and temperatures seldom reach 90 or above during the summer. This is a very fine agricultural section with dairying holding a prominent position. The large towns as Portland, Salem, and Eugene, in this area necessitates that a large proportion of the milk produced is used as fluid milk and cream and for the manufacture of ice cream. About one half of the state’s butter output was produced in this section before the war.

The area located east of the Cascade Mountains differs greatly climatologically and agriculturally from the rest of the state. The conditions are similar to those of southern Idaho and northern Utah. The elevation of this area varies from about 1000 to 4000 feet. The precipitation is light, varying from 3 to 20 inches per year. The humidity is low, evaporation rapid and there is considerable sunshine in this section of Oregon. The winters are cold and the summer hot. This is a great alfalfa, clover and potato-producing region as water is made available for irrigation. Some parts are unexcelled for dairying. The part that cannot be irrigated is stocked with range cattle and sheep.

It was about the year 1920 when the production of dairy products
in Oregon began to exceed the consumption. Shipments of butter and cheese to California were commenced.

In 1923 it was recognized by the Oregon dairy leaders that a definite planned program for dairy products quality improvement was necessary. As dairying was considered the basis around which Oregon's diversified farming system should be developed, it became necessary to take steps to consider the things which must be done to develop the industry. The improvement in the quality of dairy products, beginning with correct methods of producing milk and cream on the farms, was felt to be an all-important matter. It was recognized that outside markets were not open on salable terms to Oregon dairy products except when they compared favorably in quality with those of other surplus-producing regions. Payment for milk and cream in accordance with quality was considered of utmost importance. Other important points were considered.

The actual improvement work did not start until 1929 when a state-wide butter scoring and analysis service was inaugurated by Oregon State College. The dairy commissioner's office cooperated.

This program continued uninterrupted for 14 years until the war conditions forced a halt. Whereas Oregon butter was not acceptable on the California markets on account of low quality and variable composition at the time the program was started, after a few years the improvement effected was such that the butter was readily accepted. To illustrate some of the improvement that took place, of the churnings of butter examined during the first year (1929-1930) only 8 percent scored 92 and above, whereas during the 14th year (1942-1943) 42 percent scored 92 and above. The keeping quality, color, and composition were also greatly improved. Yeasts and molds were reduced. Specific defects were eliminated.

A similar program of improving Oregon's cheese was in operation until 1943.

Now Oregon butter and cheese have a good reputation on the California market. Losses from inferior products are no longer encountered, and the returns to the creameries and cheese factories have been increased. This program was temporarily interrupted by the war and I am sorry to admit that the quality has slipped badly. It will be some time before we can recover the lost ground.

Significant state dairy laws have been enacted in recent years. The milk-cream-and butter-grading law became effective in 1937. This provides for the compulsory grading by state-licensed graders of all milk and cream received at manufacturing plants and the payment of a minimum differential of one cent per pound fat between the grades. Milk and cream unfit to use must be colored and returned to the producer. Milk, cream and butter grades have been established by the
State Department of Agriculture. Each creamery must have in its employ a state-licensed grader who is responsible for grading and labeling the consumer packages of butter with the proper state grade, either A, B, or C. This program was very effective until the war conditions interfered with the proper enforcement of the law.

Another effective law provides for the licensing of buttermakers and cheesemakers. This was enacted in 1939. Before obtaining a license the buttermaker or cheesemaker must satisfy an examining committee appointed by the State Department of Agriculture that he is qualified to manufacture butter or cheese. If the standards of Oregon's butter and cheese are to remain high it is necessary to have these products made by qualified men.

The Oregon state legislature in 1943 passed a bill that provided for the collection from the producers of one cent per pound for all butterfat sold during the month of May each year. The fund must be used for the purpose of promoting the sale of dairy products. The Oregon Dairy Products Commission administers the fund.

A committee representing both the producer and manufacturer groups sponsored the enactment by the 1945 legislature of several significant dairy laws. One law establishes a policy of the fullest cooperation between the state board of health and the state department of agriculture. The functions of each state department are clearly delineated. One of the new laws provides for modified compulsory pasteurization and a modified method of brucellosis (Bang’s disease) control. All milk and cream and their products sold in Oregon, with the exception of Cheddar cheese, dry milk and evaporated milk (the latter two being sufficiently heat treated during manufacture) must either be pasteurized or come from herds that are disease-free, in accordance with this new law. The licensing of all pasteurizer operators following the passing of an examination is also provided for.

The Oregon Agricultural Experiment Station's program for research involving dairy products was commenced in 1937 when experiments to develop methods of preventing crumbliness and stickiness in fall and winter-made butter were started. A system of manufacturing butter entitled "The 50-45-40 method of butter manufacture" was announced in 1942. Other research involving the major dairy products manufactured has received attention by the Experiment Station.

With the large influx of people to the Pacific Coast states during the war years, greater amounts of dairy products have been purchased from the eastern states. The demand for butter exceeded the available supply. Although many shipyard, aircraft, and war plant workers have returned to their homes in the states farther east, indications are that the Pacific coast population will remain considerably above the prewar figure. The production of electric
power by the Bonneville and Coulee dam power projects will result in greater industrial activity in the northwest.

The average daily consumption of market milk in Portland now is 1/2 million pounds daily as compared with an average daily consumption of 300 thousand pounds during the years 1937-41. The consumption of ice cream and cheese has also increased. But butter is in short supply.

The total production of milk in Oregon during 1945 was 3 per cent below that during 1944. This is accounted for by the decrease in cow population of 10,000 head.

These changes in Oregon's dairy picture undoubtedly have had a counterpart in the state of Washington.

It will be some time before the prewar volume of shipments of butter and cheese to California will be reached.

The development of the Grand Coulee irrigation project in northeast Washington during the next few years will have an effect in increasing dairy production. It has been estimated that when the land in the project is completely in production about 1/2 million cows will be added to the northwest. But this will probably not increase the prewar ratio of cows to the human population.

The northwest purchases large quantities of dairy farm and dairy plant equipment, supplies and foodstuffs from middle western and eastern states.

Practically all equipment such as separators, coolers, milking machines, barn equipment, trucks, pasteurisers, freezers, churns, cheese vats, can washers, pails and cans are obtained from these states. Nearly all dairy supplies such as bottles and caps, brushes, parchment paper, washing powder, paint, corn syrup, and chemical and bacteriological supplies are also shipped in. Concentrates for dairy cow rations, such as soybean meal and cottonseed meal also account for a large business.
NEW THINGS IN DAIRY MANUFACTURING

A Resume of Recent Developments Based on Research

From the distribution of mostly raw milk, to the distribution of safe and palatable homogenized, continuously pasteurized and cooled milk automatically filled into machine-washed bottles.

From laborious batch-churning of cream in a box-type churn and working the butter on a revolving table, to the continuous manufacture of butter in all stainless steel equipment under controlled conditions.

From back breaking freezing of ice cream in a tub freezer using ice and salt, to streamlined, automatic, continuous manufacture and packaging of ice cream and dispensing it in refrigerated cabinets.

From the manufacture and merchandising of large wheels of cheese for dispensing in triangular pie-shaped sections in food stores, to merchandising rind-less, pasteurized cheese in sanitary cans, glass, or transparent film.

From no commercial manufacture of dry milks to a production of nearly 1 billion pounds in 1944 -- are some of the developments in dairy manufacturing that have been observed by those who have been engaged in the Dairy Industry during the greater part of this century.

The annual production of creamery butter in the United States increased from 400 million pounds in 1899 to 1 1/2 billion pounds in 1944. Cheese increased during the same period from 300 million pounds to 1 billion pounds. Condensed and evaporated milk from 200 thousand pounds to 3-3/4 billion pounds. Ice Cream from 24 million gallons to nearly 1/2 billion gallons. The products dry nonfat milk solids, dry whole milk, and process cheese made their appearance in commercial channels during the second decade of the century. The total of all dairy products manufactured in the United States during 1944 was 10 1/4 billion pounds. For this was used 54-3/4 billion pounds whole milk and 12 billion pounds skim milk (1).

Among the methods of processing and manufacturing adopted commercially since 1900 were: The vat-holding method of pasteurization of milk and cream, clarification of milk by centrifugal force, pasteurization by electricity, homogenization of several milk products, continuous sterilization of evaporated milk, continuous ice cream manufacture, rapid hardening of ice cream to temperatures below zero degree F., spray drying of milk.

Of dairy manufacturing equipment developed during this century may be mentioned: combined churn and butter worker, coil vat, spray vat, homogenizer, automatic vacuum milk bottle filler, direct expansion cabinet cooler for milk and milk products, automatic butter
wrapping machine, automatic can and bottle washers, recording thermometer.

Of developments in materials used for dairy equipment were: steel-chromium-nickel alloys and cast aluminum, and for milk products were: paper containers for ice cream, cottage cheese and other products, transparent moisture-proof film for wrapping cheese, aluminum foil and wax impregnated paper as a protective covering for milk bottles.

The application of the sciences: chemistry, physics, bacteriology and mathematics has greatly aided in sound and rapid development of the dairy manufacturing industry in the United States.

In giving a resume of the most recent developments in dairy manufacturing I will confine the discussion to the most important advancements made in market milk and cream, followed by butter, cheese, ice cream, concentrated and dehydrated milk and milk products and miscellaneous milk foods.

Fluid Milk

Milk. Of the 118 billion pounds of milk produced on farms during 1944 about one-half was consumed in fluid milk form as milk and cream. In cities and villages 44 1/2 billion pounds were consumed. (2)

Although many milk plants are now using the conventional vat method of pasteurization, cooling the milk on a surface cooler, and bottling and capping in the presence of air, research by dairy engineers and dairy technologists has led to the development of this method: clarification, homogenization, high-temperature short-time pasteurization in a totally enclosed apparatus, and cooling in an enclosed cooler. The milk is then conducted through a sanitary stainless steel tube to a vacuum bottle filler with which is connected an automatic capper.

By clarification is understood the removal, by centrifugal force, of the major portion of suspended matter which in milk of high quality consists chiefly of cellular material such as leucocytes and epithelial cells. Clarification effectively prevents sedimentation in bottled, homogenized milk. Although the clarifier removes dirt from milk, clarification is not a substitute for the production of clean milk, as milk produced under dirty conditions always has an undesirable flavor and contains large numbers of bacteria.

The purpose of homogenization is (1) to finely divide the fat globules to prevent the formation of cream on the surface of the bottled milk and (2) to decrease the curd tension. It is accomplished by subjecting the warm milk to a pressure of about 2500 to 3000 pounds per square inch and forcing it through a specially designed valve.
High-temperature short-time continuous pasteurization. In one type of this quite new method of pasteurizing milk the regenerative system is used. The incoming cold milk is heated by the hot, pasteurized milk using thin stainless steel plates as dividing walls. By this means the temperature of raw milk is heated to about 120-130°F, while the pasteurized milk is partially cooled by the raw milk. The warmed milk then travels to the pasteurizing section, where it is heated through stainless steel plates by hot water to a temperature of not less than 160°F. It is then held for a minimum of 15 seconds in a stainless steel tube on its way to the cooling section.

Cooling. Without exposing the milk to the light it is cooled in a plate cooler, which is an integral part of the apparatus, by means of refrigerated water to a temperature of 38 - 40°F.

When pasteurized by this method, as with the orthodox methods of pasteurization, all pathogenic bacteria, if present, are destroyed. The milk will be phosphatase negative. The apparatus is fully automatic. In the event the temperature of the pasteurized milk, before it enters the holding compartment, drops below that required, an automatic flow diversion valve will divert the flow of the milk to the raw milk intake until the temperature again is as required.

A modern automatic pasteurizer of this type may handle continuously up to 22,000 pounds milk per hour during a full working day, with no diversion of the milk, with no deviating line on the automatic temperature recorder. Some plants operate the equipment for 15-20 hours daily.

Homogenization of raw milk causes activation of the enzyme lipase with the subsequent development of a rancid flavor. When combined with pasteurization this is avoided as the enzyme is inactivated.

The curd tension of milk may be reduced about 50 per cent by standard homogenization. In a series of experiments, when milk at 120°F, having curd tensions that ranged from 53 grams to 112 grams was homogenized at 3000 pounds pressure, the tensions of the homogenized milk ranged from 20 to 36, as determined by the Hill test. (3) One method has been developed that will result in curd tensions as low as 10. In this process the cream from the milk is homogenized and then mixed with the skim milk.

Homogenized milk is generally preferred by consumers because of its more pleasing color and appearance and its more mellow flavor. In a survey it was preferred to unhomogenized milk by the majority of the consumers, who reported 20 different advantages. (4). It is considered superior to unhomogenized milk when used for both baked and soft custard, (5) but is less satisfactory, because of its lower heat stability, when used for cooked cereal and scalloped potatoes, as it may show curdling. (6) Hard water and a slight acidity of the milk will favor the curdling.
The removal of the air from milk before pasteurization has been found advantageous in preserving the vitamin C content of the milk during a short time of storage and in preventing the development of oxidized flavors. The oxygen content of milk in the udder is practically zero, but at the time the product reaches the milk plant the oxygen content may have risen to about 10-12 milligrams per liter. After pasteurization and cooling by the continuous method the milk in the bottle may contain about 11 milligrams per liter. With a deaerator installed between the pre-heating section and the pasteurizing section of the continuous pasteurizer all the oxygen from the milk can be removed. This is accomplished by spraying the milk at 115°F into the deaerating chamber maintained at about 29 inches of vacuum. It was reported that: "During 30 months of the operation of the continuous deaerator the average of 250 analyses of fresh milk was 17.19 milligrams of vitamin C per liter. The 'in-bottom' filled, the 'commercially filled,' and the 'air reincorporated' samples of 7-days-old milk averaged 15.26, 13.03 and 6.08 milligrams of vitamin C per liter, respectively. The flavor of the milk at the age of 7 days for the three methods was: "good, fair, and poor respectively." (7)

Single-service containers for milk have come into use since 1929. Recently studies were conducted to answer two fundamental questions about paper milk containers -- are they sanitary, and are they practical for the fluid milk trade? The investigation showed that they were sanitary and practical to use. After four years of using glass and paper bottles, at intervals, 95 per cent of the consumers who participated in the tests preferred the paper bottle. The reduction in the ascorbic acid content and the development of an undesirable burnt flavor when the milk was exposed to sunlight occurred less rapidly when the milk was stored in paper rather than in glass containers. In four hours the ascorbic acid content of the milk was reduced from 18.3 mg. when glass was used to 7.14 mg. when paper was used. The flavor score of the homogenized milk was reduced 2½ points after 1 hour exposure to the sun when kept in a glass bottle, and only 3/4 point when kept in a heavy-weight paper bottle. (8)

The effect of light on riboflavin in milk has also been investigated. When homogenized pasteurized milk was exposed to direct sunlight the percentage reduction in the riboflavin content, which was 1.78mg/l at the beginning, was 77.5 per cent when stored in a clear glass bottle, 4.6 per cent when stored in a brown bottle and from 5.3 to 16.9 per cent when stored in four different paper quart containers. Precaution should be taken to prevent photolysis of riboflavin in milk. (9) Sterilized cream marketed in sealed bottles is a new product covered by patent based on several years of research. It is reported that the cream can be kept for a year, or longer, at room temperature without deterioration. The product has a light color similar to ordinary cream and only a slight heated flavor.
Before processing, .1 - .25 per cent vegetable stabilizer is added to the cream. The purpose is to prevent separation during storage. The cream, preheated to 212-230 degrees F., is sterilized in continuous flow apparatus at a temperature of from 260 to 280°F for 30 seconds. The bottles and caps are steam sterilized under pressure at 275°F for 30 minutes before they are used. The containers are filled under aseptic conditions. The air which enters the bottling room is filtered and washed and the dust is collected by an electric precipitator. In the air duct are located ultraviolet lamps used to destroy microorganisms in the air by light rays. The operators in the bottling room wear sterilized uniforms, caps, gloves and masks. Representative samples from each day's run undergo a thorough laboratory examination extending over a period of several days. (10)

Sterilized milk which is high in "quick energy" value and suitable for drinking directly from the container was developed during 1945 in response to requests by the Army Quartermaster Corps. The milk was wanted for use on invasion beachheads where landing forces frequently needed a "pick-up" for sluggish appetites. The milk contains approximately 16 per cent total solids as compared with 13 per cent for average milk. The extra solids were largely sugars of different kinds and a small amount of extra fat. (11)

Cultured cream is widely used in European countries. Crème d'Isigny is a cultured cream that originated in the Normandy dairies. It takes its name from the town of Isigny in Normandy, France. A similar product was made experimentally in the United States from fine quality sweet cream containing 20 per cent fat. The cream was pasteurized at 185°F and held 30 minutes. It was then cooled to 70°F, placed in glass containers or enameled cans and inoculated with 2 per cent fine flavored lactic acid culture and ripened at 70°F for 15 hours. The containers were then vacuum sealed and placed in a refrigerator at 35 degrees F. The addition of 5 per cent sugar was preferred by many consumers, especially when the product was used with fruit, such as strawberries, raspberries and fresh apricots. This palatable, easy to digest sour cream product deserves a wider use in the human dietary. A bulletin which discusses the method of manufacture in more detail is available. (12)

Butter Progress

Butter has not been overlooked by research workers during the past few years. The efforts have been directed toward the manufacture of butter of more uniform flavor, salt and color of better keeping property, and possessing a desirable spreadability.

The age-old method of working butter by kneading has been largely discarded in favor of working it by pounding -- a very radical change.
This permits the whole process of churning, washing the granules, salting, and working to be done in the churn, which is free from internal revolving devices.

An important development was the all-metal churn. The churn is electrically operated, and is constructed of cast aluminum alloy. It is cube-shaped in form and has no parts in the interior. It is built in several sizes up to one ton butter capacity. This type of churn permits the sterilization of the interior surfaces, with which the cream and butter come into contact by means of boiling water or steam.

Consumers desire butter which has a smooth, waxy body. They object to butter which is grainy, crumbly, sticky or greasy. They do not like butter that is leaky or has a harsh, briny taste. Several research workers have done fundamental work to improve butter texture and body. One experiment station has recently announced a method of butter manufacture, termed the "50-45-40 method," which, if correctly followed, will result in butter of a fine texture and of a superior body. (13)

More efficient pasteurization of the cream, at high temperature, without scorching it, and adjustment of the hydrogen ion concentration of the cream to a definite point have been shown to greatly improve the keeping quality of butter.

A new method of pasteurization, evolved in New Zealand, has been introduced in the United States. The process is continuous in the destruction of all harmful bacteria, if present, and in a high percentage of the common lactic acid or other bacteria. Although the cream is heated to a high temperature the pasteurized cream does not have a scorched or cooked flavor. The keeping quality of the butter was found to be excellent in a series of experiments recently conducted. (14) (15)

The continuous manufacture of butter appears to have possibilities of adoption by the creameries. Several European and American methods have been developed during the last five years. As they are still in the evolutionary stage a discussion of them at this time would seem premature.

New But Old

Dry Butterfat, or butteroil is not a new product as it has been made in India and Egypt for centuries, but it is a relatively new product in the United States. Large quantities were made during the war for shipment in barrels without refrigeration to Russia and to other countries. It is probable that dry butterfat will find good use in this country in the future. In the past it was necessary to first churn the cream by the conventional batch method, but through
research a satisfactory method of continuous manufacture has been developed.

Although this process will be protected by patent, I have been granted permission by the patent right owners to discuss this new method.

1. Cream of fine quality is separated at approximately 120° F. by means of a specially constructed centrifugal separator to give a high-test product containing 90-95 per cent fat.

2. The oil is re-separated so that butteroil containing less than one per cent moisture is obtained.

3. The butteroil is continuously subjected to high temperature pasteurization at 195-200 degrees F. under partial vacuum, to steam distillation, and to partial cooling in a chamber maintained at nearly complete vacuum in a Vacreator. This treatment effectively removes all traces of moisture and insures keeping quality. Because the product moves through the vacuum chambers continuously, and is briefly subjected to the high heat treatment, the total time for vacreation treatment being only three seconds, there is no impairment of the flavor of the oil caused by the heat. Split batches have been made, using a vacuum pan and a Vacreator. The vacuum pan-treatment had a scorched flavor.

4. The moisture-free oil is congealed continuously in a machine constructed like a continuous ice cream freezer to be extruded and placed in containers.

Research has shown that the nutritive value of dry butterfat is "equal to that of butter," on the basis of animal feeding trials. Addition of vitamin D to the fat in amounts up to 20 U.S.P. units per milliliter did not have any detrimental effect on the keeping quality of the product. (16)

It should be emphasized that it is of utmost importance to use cream of the highest quality in the manufacture of dry butterfat. If made from inferior cream, even though the final product may taste perfectly bland, upon emulsification in skim milk the undesirable flavor becomes discernible.

Dry butterfat, if of good quality, may take a very important place among the dairy products. It keeps well without refrigeration and because it contains no moisture it is more practical to store it than butter, frozen cream and plastic cream. It will take an important part in the manufacture of ice cream, in baking, and in other foods where butter or cream have previously been used. The fat, if properly packaged, will keep for one year without refrigeration at ordinary warehouse
temperature, but if it is to be stored for over a year it is safer to store it at zero degree F.

Cheese, Past and Present

The high nutritive value of cheese is recognized by nutrition authorities. During 1944 a total of 1 billion pounds of cheese, not including cottage cheese, were manufactured in the United States. Of this total, 800 million pounds were of the Cheddar variety.

Only a relatively small percentage of the unprocessed cheese manufactured in the United States has been made from pasteurized milk. Pasteurization of milk which is to be used in the manufacture of Cheddar cheese has been shown by carefully conducted research and field investigation to be advantageous. (17) (18). The chief objections to pasteurization of milk for cheese have been (a) that pasteurization would favor the use of low-grade milk, and (b) that a typical Cheddar cheese flavor does not develop in the cheese when the milk has been pasteurized.

Research has shown that when low-grade milk is used, cheese of inferior grade will be obtained, whether the milk is pasteurized or not. Pasteurization is definitely not a substitute for sanitary methods of producing and handling milk or for incorrect manufacturing methods. Results from experiments when first grade pasteurized milk was used in Cheddar cheese manufacture have shown that a fine quality cheese can be obtained. It is essential that an active lactic acid culture be added to the pasteurized milk; that the manufacturing method be properly controlled; and that the cheese be ripened at about 50° F. The ripening period must be long enough to allow for the necessary chemical and physical changes to take place in order that a fine flavor and smooth, waxy body are produced in the cheese. This will take longer than is required for cheese made from raw milk. A typical Cheddar cheese flavor will develop. Pasteurized-milk cheese, if correctly manufactured and ripened, is generally free from the high-acid, bitey and bitter flavor which is present in so much raw-milk cheese on the market.

A modification of the phosphatase test applicable to cheese has recently been made. (19)

The method of packaging Cheddar cheese at time of manufacture in valve-vented cans, and curing the cheese in the cans has been perfected during the last ten years. (20) The desirable features of this method are: (a) the cheese is completely protected against contamination; (b) the cheese is free from rind and is thus completely edible; (c) molding is prevented; (d) cases of cheese can be conveniently stored in refrigerators; (e) shrinkage is prevented; (f) several cans can be stored in a home refrigerator.
The round cans contain \(\frac{3}{4}\) lb. and 2 lbs. cheese. The square can contains \(2\frac{1}{2}\) and 5 lbs.

The cheese may be sliced prior to placing it in the can. This is very desirable when the cheese is to be used for sandwiches, especially at lunch counters. A parchment paper ribbon may be inserted between the slices.

Modern Package

The modern trend appears to be the merchandising of food in single service containers, attractively packaged. Another method of packaging cheese which has recently been developed is that of wrapping bricks of cheese in special transparent, moisture-proof sheets of different composition. The cheese may be ripened in this material or the cured cheese may be printed and then wrapped. The cheese will all be edible as there is no rind.

It is my opinion and also that of many cheese manufacturers and distributors, who have expressed themselves, that the merchandising of uniformly high quality pasteurized milk cheese in attractive containers will have a stabilizing influence on the cheese industry and will result in greater cheese consumption.

Other recent research in the cheese field has led to the perfection of methods for the manufacture of Romano and Parmesan type grating cheeses, Roquefort type cheese, dehydrated cheese, and army cheese spread.

The Italian type cheeses were imported in considerable volume before the war. Romano-type cheese of desirable flavor characteristics was developed at one agricultural experiment station (21) and a grating cheese which possesses a high piquant flavor and good grating qualities was developed at another station (22). A characteristic flavor in the grating cheese was produced by adding homogenized pasteurized cream to raw skimmed milk in the cheese vat. The cheese was ready for consumption after five months' ripening, although 10 months was preferable.

The research at experiment stations to develop Roquefort-type cheese of excellent quality has been successful. Roquefort cheese made from homogenized raw milk or from milk heated in a Vacreator at 165-170 degrees F. has been pronounced excellent in flavor and body and texture by connoisseurs of this tasty cheese. Mould cultures of desirable type have been developed by research laboratories and are available to cheese factories. (23) (24)

There was a need during the war period for the conservation of space on shipboard when food was shipped overseas. For this reason
many food products were prepared in a dried form. A satisfactory method of dehydrating and compressing Cheddar cheese was developed. By removal of the water from the cheese the weight was reduced about one third. By compressing the cheese into rectangular blocks the space conserved, as compared with the original cylindrical form, was from 40 to 46 per cent. The moisture content of the dry cheese was reduced to below 3 per cent. Dehydrated cheese may be used in cooking, as for macaroni and cheese and Welsh rabbit. It may also be used with salads, desserts, in soup, and in spreads. (25)

Army Cheese Spread was made during the war period in considerable amount. In its manufacture was used butter, Cheddar cheese curd made from pasteurized milk, and nonfat dry milk solids. It was permitted to contain: not over 0.17 per cent vegetable gum, not over 2 per cent emulsifying agent, not over 0.1 per cent benzoate of soda, not over 0.1 per cent antioxidant, and approximately 2 per cent salt. In addition, not less than 8,500 U.S.P. units of vitamin A was to be added per pound of finished product.

In manufacturing army spread, the ingredients are thoroughly mixed and comminuted while heating in a homogeneous mass. The mixture must be heated to a temperature of not less than 160°F., and not more than 180°F. The containers must be filled with the product at a temperature not lower than 145°F. and must be held at a temperature not lower than 142°F. for not less than 20 minutes, the latter holding time to be included in the cooling process.

The finished product must not oil off when held for 24 hours at 120°F. It was required to have a butterfat content of not less than 56 per cent and a moisture content of not more than 29.5 per cent. (26)

Ice Cream

America's favorite food -- ice cream -- is continuously being improved. Research workers have directed their attention to improving: (1) flavor, (2) texture, and (3) sanitary quality of this delicious food. Finer quality cream, milk solids, flavoring, fruits, nuts and other ingredients are now used, so that ice cream will have a fresh, palatable flavor. A finer textured ice cream is being produced through better proportioning of the ice cream ingredients, more efficient processing, the use of the continuous ice cream freezer, and quick hardening of the ice cream at a temperature of -10°F. or lower, in order to produce minute ice crystals. The filling of pint and quart cartons direct from the freezer has become common. Research has shown how undesirable stale, oxidized or metallic flavor, and coarse and sandy texture may be avoided.
The method of continuous flash pasteurization was found satisfactory, and the dual use of Vacreator vacuum pasteurizer for condensing the milk for ice cream mix and for pasteurizing the mix was found advantageous. (27) (28)

Dry Ice Cream Mix was made in considerable quantity during World War II. Ice cream made from dry mix was very popular among the men and women of our armed forces. Ice cream made from powdered mix was a great morale builder and was an important part of the daily diet of wounded men in overseas hospitals or on board transports. Enough dry ice cream mix to make 75 million gallons of ice cream was made during 1945. (29)

It was extremely fascinating for ice cream makers in the American dry mix factories to manufacture a product which would be sent to far distant places and become the most popular of the foods of the men and women of the army and navy.

In brief the method of manufacture is as follows:

1. Combine the milk solids, stabilizer and \( \frac{1}{4} \) the sugar to be used together in such proportions as to obtain the desired ratio of solids to one another. For example, if desired to make an ice cream powder which when reconstituted tested 12 per cent fat, 10.8 per cent solids, 15 per cent sugar and 0.24 per cent stabilizer, combine cream, whole milk, sugar and stabilizer together in such proportions that for every one pound of fat there would be 0.9 pound of serum solids, 1.25 pounds of sugar, and 0.02 pound of stabilizer.

2. Preheat to 170°F. for 20 minutes.

3. Condense as far as the stabilizer used will permit (32 to 36 per cent).

4. Homogenize at 2500 lbs. pressure at 130°F. or higher.

5. Cool and store until sufficient volume is available for drying.

6. Preheat to 150°F. In some plants it may be desirable to add the sugar and stabilizer at this point rather than before condensing.

7. Spray a rather coarse particle if this can be done without too great a sacrifice of plant capacity.

8. Mix remainder of sugar with dried mix in proper proportion to obtain the desired sugar-fat ratio. In this case this ratio would be 15:12. At the same time the powdered vanilla should be added.
9. Package and gas in usual manner. (30)

The army required that the product should contain not less than 27 per cent total fat, not less than 9.75 per cent protein, and not over 2.25 per cent moisture.

For reconstituting, 4 1/2 pounds of the powder is mixed with seven pints water. A wire whip may be used for mixing. (31)

Five-ounce packages of dry ice cream mix can now be obtained in food stores.

Dry Whole Milk

Dry Whole Milk was manufactured in insignificant amount before 1941 (only 30 million pounds in 1940), but with America's active participation in the war the problem was to furnish the army and navy personnel with an adequate and nutritious ration. Dry whole milk was required in large amounts. During 1944 a total of 178 million pounds were manufactured by 97 plants. Most of this was for the men of the armed forces. The standard container was a cylindrical can with a capacity of five pounds powder.

To meet army specifications the product was required to have a fat content of not less than 26 per cent and a moisture content not above 2.25 per cent. The acidity, copper, iron, bacteria and sediment content was to be quite low. (32)

Research at several experiment stations has been in progress with the view of improving the flavor, keeping quality and reconstitutability of dry whole milk. Some of this has been in cooperation with the Army Quartermaster Corps Subsistence Research and Development Laboratory (now Quartermaster Food and Container Institute for the Armed Forces). Very marked improvement, especially in the keeping quality and method of packaging, has been effected. (33) Without going into a detailed description of the methods of manufacture and packaging I shall briefly mention the methods which have been found by research and experience to be satisfactory, but I hasten to mention that perfection has not been reached in the manufacture of dry whole milk, which, whether when fresh or after storage, in the reconstituted form is equivalent to fine quality fresh homogenized milk. But an acceptable product can be made.

For manufacture, the fresh whole milk is adjusted in composition so that it contains a maximum of 2.675 pounds solids not fat per pound fat. The method of manufacture varies with the different drier systems. With the spray method a typical sequence is the following:
1. Clarify the raw milk with a centrifugal clarifier.

2. Pasteurize at 170° F. for 20 minutes, or 230°-240° F. in a continuous flash heater.

3. Condense the milk to a 3:1 concentration. The condensed milk will contain about 40 per cent total solids.

4. Homogenize the condensed milk at 120° - 130° F. at a pressure of 3000-4000 pounds per square inch and cool to 40° unless dried at once.

5. At a high pressure, force the homogenized condensed milk at 140° F. through a spray nozzle into the drying chamber. The milk becomes atomized as it leaves the nozzle. The fine spray at this point comes into contact with the hot air blast and the milk quickly loses its moisture. A high spraying pressure, using a nozzle with a small orifice results in a fine-grain powder, and a low spraying pressure, using a nozzle with a large orifice, results in a coarse-grain powder. Overheating results in a scorched flavor.

6. The packaging operation consists of (a) automatically filling cans with powder; (b) evacuation of the cans; (c) adding Nitrogen gas, and (d) sealing. The dry milk before packaging may be cooled by means of refrigerated air or by carbon dioxide gas.

   The oxygen content of the gas surrounding the powder particles and of the gas in the headspace of the cans usually increase slowly during the first 7-10 days after the cans have been sealed. This is because of the escape of oxygen from the bubbles of air in the interior of the powder particles until an equilibrium of gases in the can has been reached. (34)

   Whole milk powder in cans that have not been evacuated keeps poorly. An oxidized, or cardboard flavor develops. Published data have shown that as the oxygen content is reduced an improvement in the keeping quality is effected. (35)

Reconstituting Dry Whole Milk

Research is now in progress at one agricultural experiment station, having for its purpose the improvement of the reconstitutability of dry whole milk. This is the most important problem of the dry whole milk industry. The results obtained so far have shown that to produce reconstituted milk which compares favorably with fresh homogenized milk in physical appearance, when water at 75° F. and an electric malted milk mixer are used when reconstituting, the milk
sprayed must contain the fat globules in a finely dispersed form, the powder particles must be uniformly small, and overheating during drying must be avoided. (36)

Recently tablets have been made from a mixture of dry milk, butterfat and sugar, compressed by hydraulic pressure, from which a palatable drink was prepared by using either hot or cold water. The tablets could be crumbled by hand to a powder. Cocoa, coffee, tea, custard and milk pudding blocks were also made. When melted fat was added, to give a fat content of 20 per cent of the mixture, on cooling in moulds these blocks contained the fat as a continuous phase which cemented the material. Then blocks could be broken into the desired size and stirred into boiling water. Such blocks could also be eaten without reconstitution and were found to have a good keeping quality when wrapped in waxed paper. It was reported that they could be stored for eight months at 68°F and retain their desirable properties. (37)

In order to find out how dry whole milk and nonfat dry milk solids would be accepted by the consumer a survey was recently made. The study indicated that consumer acceptance of dry milks was neither an unqualified success nor wholly a failure. Of 247 women who expressed their opinion, 22 per cent named the difficulty of reconstitution and the taste as the two chief qualities disliked about dry whole milk. This would indicate need for a simple device for reconstituting dry whole milk and for further research to improve the flavor of this product. (38)

Dry Cream Mix for whipping by aeration is a newly developed product. Its composition is 68.8 per cent fat and 18.5 per cent milk solids-not-fat, 11.5 per cent sugar and 0.69 per cent whipping agent.

For whipping, water is added to give the liquid product a fat content of 30 per cent. The cream can be whipped instantaneously by releasing it from a container which contains nitrous oxide gas under high pressure.

The whipped product is quite similar to that whipped by the same method from fresh cream.

Dry cream mix may be stored satisfactorily in sealed containers from which the air is removed and replaced with nitrogen. (39)

A Sweetened Dry Nonfat Solids Milk Product made by the spray process from sweetened condensed skimmed milk is a recent development. It contains 59 per cent sucrose, 39 per cent milk solids-not-fat and 2 per cent moisture. It is reported that this new product has found great favor with manufacturers of chocolate coating, pie filling, cake frosting, various types of dry milk preparations containing malt
and cereal, and it has been used by bakeries, ice cream plants, and for chocolate milk drinks.

Frozen Concentrated Milk appears to have some market possibilities in areas where fluid milk is scarce. It would also be satisfactory to use on ocean-going ships. Studies during recent years on the manufacture of frozen concentrated milk indicate that a product which keeps well and reconstitutes satisfactorily can be made. One method of manufacturing frozen concentrated milk developed is:

"Clarify high quality milk, pasteurize at a high temperature, condense to one-third the volume, homogenize, freeze in an ice cream freezer, place in packages, and finally finish freezing in a room maintained at -10° F. All equipment should be copper-free. The milk may be defrosted and reconstituted to the fluid state by undisturbed thawing in a vessel containing the necessary amount of water at 180° F. required for bringing the milk to the concentration desired." (40)

A study which involved the storage of whole milk, condensed to one-third its volume, for 18 to 20 months at -12° to -15° F., has just been completed. (41) One-quart paraffined fiber containers were used for the milk. Examination of samples of milk at intervals showed very slight change in the score of the milk. At the end of the storage period the flavor of the reconstituted milk was very similar to that of the milk when it was placed into storage.

The fresh milk was pasteurized at 170° F, for 30 minutes followed by condensing and cooling to 40° F. All stainless steel equipment was used.

Reconstitution was done by adding 2 quarts hot water at 165° to 170° F, to the 1 quart block of frozen milk in a container. The reconstituted milk appeared like fresh, homogenized milk in physical condition.

The addition of from 1.5 to 3.0 per cent dextrose to the condensed milk was of no advantage. Pre-freezing the condensed milk in a continuous ice cream freezer was of no advantage. It had the disadvantage that about 20 per cent air was whipped into it. This caused foaming during reconstitution.

Cheese Whey is a potential source of a number of products. In 1944 a total of 141 million pounds of dry whey was manufactured. The product contains lactose, albumin, minerals and vitamins. The chief use of dry whey is in the preparation of poultry feed. The constituents of whey also find use in the manufacture of human foods, plastics and pharmaceutical products.

The Bureau of Dairy Industry, U.S.D.A., has been active in
conducting research on whey utilization. The chief of the bureau, C. E. Reed, has reported on the following six ways of utilizing whey:

Separation of the whey constituents by a new method based on removal of the lactose from concentrated whey by alcohol.

Production of a syrup containing a mixture of dextrose, galactose and lactose.

Utilization of whey solids in the manufacture of taffy, fudge, and oamels. A new type of candy, containing 40 per cent whey solids was developed.

Incorporation of whey solids in dehydrated pea soup.

Preparation of a canned pudding, utilizing whey solids in place of eggs.

New products, such as plastics, from the lactose in the whey. One of these is polymethylacrylate, which is reported to have optical properties of the commercial methylacrylate plastics and possessing a high degree of elasticity and solubility which permits its use in impregnating fabrics, in insulation and numerous other industrial applications.

An important use of lactose from whey is in the manufacture of the "Wonder Drug" penicillin. In 1944 a total of 5 million pounds were used for this purpose.

Of 7 1/2 million pounds lactose in 1942 about 3 million pounds were used in baby foods, about 2 1/2 million pounds for pharmaceuticals and 2 million pounds were used in various food and industrial products. The methods of manufacture have recently been summarized. (42)

We can look forward to seeing further expansion in the use of whey solids as new methods of production are developed through research.

Dairy Spreads utilizing cream, milk, dry milk, condensed milk, cultured milk, with added color, vitamins and flavor, have emerged during the past two or three years.

Future Developments

The Future. What significant developments will likely take place in the dairy manufacturing field during the next few years?

A greater percentage of clarified, homogenized, and short-time pasteurized milk will likely be marketed. Soft curd milk will find
greater use. Attention will be given to retaining the vitamins present when the milk is produced.

**Single-service containers for milk, cream, chocolate milk, and buttermilk will become more popular.**

**Sterilized cream in single-service containers will find wider use.**

**Evaporated milk which is free from a cooked flavor will be developed.**

Dry whole milk will become a staple article in grocery stores. The development of stale and oxidized flavors in the product during storage will be overcome. The reconstitutability of the milk will be greatly improved and simple appliances for use when reconstituting the dry milk will be developed. Dry whole milk in suitable containers that will, at ordinary room temperature, maintain its fresh flavor for a year or more will be developed.

**Dry ice cream mix will be further developed.** It will be extensively marketed in packages through retail channels. A good market will be found for this product in small towns and in rural areas. It will be used to a large extent by the 15-20 percent of the housewives who make their own ice cream. (46) It will become popular on ocean-going ships.

Great developments can be foreseen in the cheese industry. The manufacture of a much larger amount of cheese from pasteurized milk will take place. Manufacturing methods will be greatly improved. Through the use of good cultures, the use of precise manufacturing methods and better curing methods the quality of cheese will be improved and stabilized. Cheese will be merchandised in attractive containers or wrapping materials such as plastic film. Attention will be given to research on several varieties of cheese.

The quality of ice cream and novelties will be further improved and standardized.

**Butter** was one of the foods that was insufficient in quantity during several war years. The American people clamored for more butter. Perhaps during the next few years the supply will again become adequate. Now is the time to intensify research. Now is the time to extend quality improvement so that butter only of finest quality shall be manufactured and marketed. Grading of milk and cream and payment in accordance with quality is of paramount importance. Efficient manufacture is essential as a concomitant of quality production and to keep the cost reasonable. A great amount of research is needed to improve and standardize the quality and keeping property of butter. The flavor should be improved. The
body should be waxier in much of the butter made and the texture could be more compact so as to prevent leaking of brine. As millions of pounds of butter are generally placed in cold storage during spring and summer, for fall and winter consumption, research is needed on problems involving flavor deterioration during storage. The American people need and like butter and will eat considerably more of it provided it is of the top quality.

REFERENCES

1. Agricultural Statistics, United States Department of Agriculture.

2. Farm Production, Disposition, and Income from Milk, 1944-45. Bureau of Agricultural Economics, United States Department of Agriculture.


12. Wilster, G. H. and Yang, Ho-Ya., Preparation and Uses of Cultured Cream. Cir. 251, Oregon Agricultural Experiment Station, Corvallis, Oregon, 1941.


15. Fabricius, N. E., and Bird, E. W., The Quality of Butter Made from Vacuum-Pasteurized and Vat-Pasteurized Lots of the Same Cream. Bul. 284, Iowa Agricultural Experimental Station, Ames, Iowa, 1940.


29. Tracy, P. H., Powdered Whole Milk and Mix. Ice Cream Trade Journal, 41, April, 1945.

30. Tracy, P. H., Dry Ice Cream Mix, in Ice Cream Trade Journal 41, 9, 1945.


NEW MILK PRODUCTS

In the near future, the problem of utilizing milk by-products that we have previously wasted or fed to animals will be a major problem for the dairy industry. With this fact in mind the results from recent developments are reported here.

The general utilization of milk during recent years is shown in the following table:

<table>
<thead>
<tr>
<th>Year</th>
<th>Milk</th>
<th>Butter</th>
<th>Cheese</th>
<th>Other Products</th>
<th>Fed to Livestock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1935-38</td>
<td>41.5</td>
<td>41.0</td>
<td>6.3</td>
<td>8.6</td>
<td>2.6</td>
</tr>
<tr>
<td>1939</td>
<td>41.3</td>
<td>40.4</td>
<td>6.5</td>
<td>9.1</td>
<td>2.7</td>
</tr>
<tr>
<td>1940</td>
<td>40.6</td>
<td>40.0</td>
<td>7.0</td>
<td>9.7</td>
<td>2.7</td>
</tr>
<tr>
<td>1941</td>
<td>39.6</td>
<td>33.3</td>
<td>8.1</td>
<td>11.4</td>
<td>2.6</td>
</tr>
<tr>
<td>1942</td>
<td>40.6</td>
<td>34.2</td>
<td>9.1</td>
<td>12.8</td>
<td>2.7</td>
</tr>
<tr>
<td>1943</td>
<td>44.6</td>
<td>35.6</td>
<td>8.2</td>
<td>10.9</td>
<td>2.7</td>
</tr>
<tr>
<td>1944</td>
<td>46.3</td>
<td>30.0</td>
<td>8.4</td>
<td>12.6</td>
<td>2.7</td>
</tr>
<tr>
<td>1945*</td>
<td>46.7</td>
<td>27.3</td>
<td>8.9</td>
<td>14.5</td>
<td>2.6</td>
</tr>
<tr>
<td>1946#</td>
<td>48.8</td>
<td>24.4</td>
<td>8.9</td>
<td>15.3</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Source of data: Borden's Economic Digest 2: Sept. 1946.

* Preliminary estimate
# Tentative estimate

From the above data it can be seen that there have been two major changes in the utilization of milk. There has been a definite increase in the production of the products other than fluid milk, butter, and cheese. The production of cheese has increased appreciably while butter has dropped materially. Many of the products coming under the column of other products are reported in this paper.

We have had available 11 billion pounds of whey from the manufacture of cheese and casein annually. Eighty per cent of this amount is either wasted or fed to animals. We recover only 8 per cent of the protein of skim milk or buttermilk if it is fed to hogs and the quality of the protein is appreciably lowered. (2) Some investigators state that 10 per cent to 12 per cent of the protein may be recovered.

The United States Department of Agriculture (3) has forecast that the wartime developments in the use of nonfat dry milk solids for the preparation of a great variety of foods will probably assist in maintaining domestic production above prewar levels. They forecast a casein production in 1947 twice as high as that of 1946 and a large increase in the production of sweetened condensed skim milk.
Some of the new developments for increased utilization of milk and milk by-products are considered in the following:

Caramel Milk

This new beverage was developed during the war by the Department of Agriculture and an evaporated milk firm. It is manufactured by boiling sugar and milk in an open kettle. The caramel mixture is combined with plain and condensed milk and canned the same as evaporated milk is canned. USDA believes it may be used to advantage in the home, soda fountains, and restaurants, not only as a drink but as a base for ice creams, sherbets, custards, puddings, and fountain drinks such as milk shakes, malts, and floats.

Sterilized Milk

Although the evaporated milk industry has for many years manufactured sterilized milk that is palatable, greater emphasis was placed on this product during the war because of transportation and storage requirements of our armed forces. A new sterilized product was developed in 1945 in response to the request of the Army Quartermaster Corps. It contained approximately 16 per cent total solids and could be drunk from the container by our troops. Recently patents have been granted on new methods of manufacture of sterilized milk and the future will undoubtedly see sterilized milk placed on the market that does not have an objectionable caramelized flavor.

Dry Whole Milk

Dry whole milk was manufactured in insignificant amount before 1941 (only 30 million pounds in 1940), but with America's active participation in the war the problem was to furnish the army and navy personnel with an adequate and nutritious ration. Many millions of pounds of dry whole milk were supplied to our armed forces during the war. Future research in overcoming flavor defects and improving reconstitutability will aid in maintaining production of this new product.

Dry Milk Combinations

Many foods have been developed recently in which powdered milk is used. Custards of different flavors, dry pie mix and dry cake mix have been successfully prepared.

Powdered milk and powdered eggs, whipped up into frothy protein-rich egg-nogs are now being used in hospital diets for cutting by a third the long periods of convalescence after an operation or severe
illness (6) In addition, the simple mix is daily performing life-saving roles in the treatment of bad burns and in giving surgery subjects that extra bit of stamina they need before an operation. Any kind of flavor may be added to increase its palatability.

Tablets made from dry whole milk, butterfat, and sugar, and compressed by hydraulic pressure have been developed. (7) The tablets may be added to either hot or cold water to make a palatable drink. Cocoa, coffee, tea, custard, and milk pudding blocks have also been made. Melted butterfat is added to give a fat content of 20 per cent and on cooling the fat in a continuous phase cements the material. They may be consumed dry also.

Sterilized Cream

Sterilized cream, with a keeping quality so good that it may be kept for longer than a year at room temperatures has now been placed on the market in sealed bottles. (8) A vegetable stabilizer is added before processing. The cream is preheated and sterilized at temperatures of 260° to 270° F. It is then bottled under aseptic conditions. For table use cream of 18 per cent butterfat is used. Sterilized whipping cream contains 30 per cent butterfat.

Dairy Spreads

Types of new dairy products now on the market are dairy spreads. The products are generally (a) whipped butter, (b) a combination of whipped butter and other dairy products, (c) a homogenized water-in-oil emulsion made from butter and other dairy products, (d) or a liquid oil-in-water emulsion discharged under nitrous oxide pressure resulting in a whipped butter spread.

Dry Cream Mix

Dry cream mix along with many of our other dried dairy products, is a relatively new product. Its composition is 68.8 per cent fat, 18.5 per cent solids-not-fat, 11.5 per cent sugar, and 0.69 per cent whipping agent. Water is added in reconstituting to give a product containing 30 per cent fat for whipping purposes. This product is now being used in restaurants, hotels, and institutions as well as the home.

Dry Butter and Butter Oil

This product is a new development in the dairy industry. Several different methods of manufacture are used. One method is
continuous. With this method the fat is removed from high-testing cream, pasteurized at temperatures of 195° to 200° F., under partial vacuum, and then packed in barrels or in cans. In one method perfected by Dr. George E. Holm, in charge of the Bureau of Dairy Industry fat-spoilage research, butteroil is extracted from the butter granules or finished butter by melting and is then placed in cans, evacuated and gaspacked with nitrogen. It is necessary to remove all of the oxygen to prevent fat spoilage. Butteroil and skim milk powder are mixed together when reconstituting for use in tropical countries. (10) (11)

In Australia, a product similar to this is now being manufactured. It is called "Tropical Spread" and contains 1 per cent salt, 2 per cent spray-dried skim milk, 77 per cent dry butterfat, and 20 per cent fully hydrogenated butterfat. (12) During the war Australia produced 8,330,844 pounds of "Tropical Spread" and concentrated butter for the armed forces of the Allied Nations.

Another product called "Butter Concentrated Hardened" was manufactured in Australia during the war. It is especially suited for tropical use. One part water to five parts butter are used in reconstituting. In the manufacturing process there is no loss of vitamins A or D and it has a caloric value of 4,000 calories per pound. Australia produced 2,769,264 pounds of "Butter Concentrated Hardened" during the war.

**Dry Ice Cream Mix**

New developments in the method of packaging dry ice cream mix have helped in increasing the production of this product. Although it cannot be considered a new product, new developments in its manufacture have made it available for use all over the world. The armed forces used millions of pounds of this dairy product during the war and considerable quantities of it will undoubtedly be exported in peacetime trade in the future. Housewives in small towns and in rural areas will be able to purchase dry ice cream mix of high quality in food stores for use in the home. (13)

**Ice Cream Combinations**

There have been many new developments in combinations and flavors of ice cream. During the war 2 per cent alamat was used as a flavoring ingredient. (14) Alamat is made from sweet potato flour and in using 2 per cent alamat an ice cream was produced that had a distinct flavor with satisfactory color and melting properties. More use of different fruits and other flavoring ingredients will be developed in the near future.
Skim Milk Products

A new product that utilizes skim milk and potatoes can be made in the form of wafers, sticks, or croutons. (15) They differ from potato chips in that they contain skim milk solids but no fat. It is a product that will promote the use of skim milk, will also add a new outlet for potatoes, and provide a new product that has a nutritional and flavor appeal for bakers, biscuit and specialty manufacturers. It is made by whipping air into a mixture of skim milk, rice, boiled potatoes, salt, pepper and other flavoring.

A concentrated skim milk product containing 25 per cent to 30 per cent solids content that can be whipped to an overrun of 250 per cent has been developed for use by bakeries. (16) This product will whip to a stiff white foam with high stability as is done with egg whites. Fruit whips similar to a product from egg whites have been prepared by adding sugar to this product and stabilizing the whip by stirring fruit pulp into it.

Another new product from skim milk is a dry nonfat solids milk that is sweetened. It contains 59 per cent sucrose, 39 per cent solids-not-fat, and 2 per cent moisture. The manufacture of this product has been limited because of the sugar shortage, but it will probably find great use in the manufacture of foods by food manufacturers. Consumers are now aware of the great nutritional value of milk solids-not-fat and this will aid in the development of new uses for this product.

Casein

Casein has found many new uses in recent years and has developed into a 20 million dollar industry annually. (17) Casein is used in three general ways: (a) in nutrition, (b) medicine, and (c) in chemurgic industries for the manufacture of many products ranging from paper to clothes.

It is particularly important in the manufacture of coated papers and paints. Because of their waterproof quality and durability, casein-coated papers have been in great demand for such items as labels, photographic paper, indicator sheets, maps and certain forms of educational literature where appearance is an important factor.

The paper industry is now using one half of the casein produced. Casein water paints have been found easy to apply, inexpensive, and may be washed. It has found new use in the manufacture of resin-emulsion paints. Many new plastic products like buttons, knobs and ornaments are now made from casein. Seven per cent of the casein now goes into the manufacture of these products. It is also used in the manufacture of wall papers to impart body, as well as a binding
agent in the manufacture of wall board, to stabilize rubber latex compounds, and in finishing leather goods. (16)

Bristles made from casein are no longer in the experimental stage. Research was commenced four years ago at the Eastern Regional Research Laboratory in Philadelphia to find a substitute for imported bristles and has reached a successful conclusion. (19) The artificial fibre was developed by Dr. Thomas L. McMeekin and his associates. The interest created by manufacturers has caused the opening of a new plant at Salesbury, Md., for the manufacture of casein bristles and brushes using the process developed by the Department of Agriculture.

The artificial bristle is made by extrusion of a mixture of casein and water through a suitable die, and then subjected to finishing operations. The final product resembles horsehair or pig bristle. It can be produced in any length desired and in a range of diameters. The bristle is particularly suitable for paint brushes since it is resistant to oils and organic solvents. Casein from waste skim milk is the source of the constituent used in making the bristles. Although the supply of natural bristles has improved, it is anticipated that there will be an increasing demand for high quality, low-cost artificial bristles.

Casein Fibre for Clothes

Although protein base fibres have been manufactured for many years, principally in Italy, a successful protein-base fibre was not produced commercially in the United States until 1939 when the National Dairy Products Corp. commenced manufacturing a fibre from casein of milk. (20) "Aralac," their trade name, is a light, fluffy and resilient fibre. It is being manufactured at the rate of several million pounds a year. It may be used alone or blended with other fibres. It is warm, absorbs moisture quickly like wool, it lends crease and wrinkle-resistance to fabrics, it is soft and drapes well. It requires special care in dyeing, but if properly handled it produces effects of unusual beauty.

The type of blend or ultimate use pre-determines the procedure which will be used in processing textile combinations containing "Aralac." The casein is chemically treated and heated to a honey-like consistency. The liquid is forced through tiny nozzles of spinnerets to emerge in a continuous filament. The soft fragile casein fibres are given a complex but inexpensive chemical treatment which rearranges the molecular structure, making the casein chemically akin to resin.

"Aralac" is used to replace rabbit hair in hats, in woven and knit goods, sports wear, interlinings, neckties, and numerous other articles of clothing. It was first used in upholstery in 1942.
The cushions and upholstery held up very well after pounding tests equal to five years in a home. Cushions of "Aralac" lose little of their thickness and are highly resilient. The fibre does not move up or down in upholstery and pillows will hold their shape without constant patting. It has been found ideal for comforters, mattresses and interlinings due to its light weight and warmth. (21)

"Aralac" is now being considered in surgical work because it is inexpensive, plentiful, extremely uniform chemically, and has physical properties which recommend it for use in surgical work. (22) A pledget made from "Aralac" to stop bleeding does not need to be removed. It is absorbed as was shown in experiments on cats by Spitz, Ziff, Brenner, and Davidson. They found that casein fibre is rapidly absorbed after septic implantation in the brain, muscle or subcutaneous tissue of the cat. They found no toxic effect on the cortical cells.

The price of "Aralac" is cheaper than wool but more expensive than rayon or cotton. It has not varied from 64 cents a pound although the price of casein has varied from 15 cents to 30 cents a pound. This comparison along with the statement that it can be produced cheaper, would indicate that it probably will be an important fibre in the future of the textile industry. (23) The textile industry must have a low cost fibre for its manufacturing purposes. The expansion of the casein fibre industry will depend in a postwar economy on relative price and relative quantity. Further development of the wet and dry strengths will enhance its competitive position.
Cheese Spread

A cheese spread was developed for the army during the war. (24) In its manufacture was used butter, cheddar cheese curd made from pasteurized milk, and nonfat dry milk solids. This spread contained 56 per cent butterfat, not more than 29.5 per cent moisture, 2 per cent emulsifying agent, 0.1 per cent antioxidant, 0.1 per cent benzoate of soda, 0.17 per cent vegetable gum, and not less than 8,500 units of vitamin A per pound. The finished product must not oil off when held for 24 hours at 120° F.

"Homo cheese", a similar cheese developed in Australia during the war, is reported to have a fine flavor and a good texture. It did not oil off when kept for six days at a temperature of 145° F. Australian dairy experts predict a promising future for this new cheese. (25)

Grating Cheese

Due to the lack of highly flavored dry cheese used for grating purposes which had been imported before the war, a cheese of this type was developed in the United States. Phillips made a cheese having a decidedly characteristic odor and a good body for grating. It was made from Holstein milk and use is made of rennet paste rather than rennet for enhancing the flavor. In another method on which an experiment station has done research, the flavor which comes from the free fatty acids such as butyric, is developed faster by homogenization of the milk.

Dehydrated Cheese

A dehydrated cheese was developed during the last war. (26) The weight was reduced one third by removing all of the moisture. By compressing, the size was reduced 40 per cent to 46 per cent. This type of cheese was developed to save shipping space. This cheese may be used in cooking and for salads, desserts, in soup, and in spreads.

Dried and Condensed Whey

Dried and condensed whey have found many new uses in confections, bakery goods and cheese foods. In confections they are used to replace the skim milk in fudge and some of the caramel. Whey fudge and whey caramel are two new candies manufactured. In Canada up to 30 per cent dried whey solids have been used in the manufacture of fudge, caramel and taffy candy. (27)

In bakery goods, condensed whey has been found to produce a more
cake-like texture than skim milk in sweet bakery products. Canned whey pudding is a new product. (28) It is an intermediate product between canned plum pudding and canned nut bread or brown bread, with less shortening and richness than plum pudding but more cake-texture and sweetness than canned breads.

Whey gives it a pleasant flavor, improves the body and leavening, and is high in nutritional value. Whey pudding contains 22 percent whey solids. Puddings of different flavors have been developed and fruits have also been used in whey puddings. A dry mix for puddings is also a new use for whey. Canned cream style soups and sauces are now being manufactured that contain 3.5 percent to 5 percent whey solids. Newest uses loom in the field of medicine.

During the war, whey solids were used to replace milk solids—not-fat in the manufacture of ice cream. (29) Leighton found that whey solids improved the body and the whipping qualities of the mix. The use of whey solids in the manufacture of ice cream will undoubtedly be continued in the future.

Lactose

Whey contains 90 percent of the milk sugar or lactose found in whole milk. A yield of 4 pounds per 100 pounds of cheese, or casein whey can be obtained.

Because of its nutritive value it has found new uses in the preparation of baby foods to increase the lactose content. (30) One of the major uses for whey was developed during the war when penicillin was discovered. Lactose is used in penicillin manufacture as a nutrient for the mold which produces penicillin, and to regulate the acidity of the medium. As the fermentation process proceeds, the alkalinity of the culture medium increases to a point where the penicillin molds cease to grow. Lactose is used as a carbohydrate to regulate the acidity of the medium. It has been estimated that 4,610,000 pounds of lactose was used in this industry in 1946. (31)

One of the newest uses of lactose is in the medicinal and pharmaceutical fields. Lactose is used in hypodermics. It is used in tablets because it is harmless, soluble, odorless, and the small quantity is practically tasteless for compressed tablets and vitamin capsules. Greater uses will be found in these fields for lactose.

Chemical Products From Whey

Although the manufacture of lactic acid from whey has been carried on for years, new developments in the use of lactic acid has increased its production. (32) Before the war approximately 5 million
pounds of lactic acid were produced annually. Now its production has doubled. Its main uses in the United States are in the leather industry, for packing olives, as a modifier for cows milk in infant feeding, and in the manufacture of plastics.

In Australia, where its uses have developed most extensively to replace imported acids, it is used in food industries as an acidulant in fruit juices, cordials, jams, pickles, confectionery, and jelly crystals. (33) It is also used as a mordant in the dyeing of textiles, the leather industry, and in the manufacture of pharmaceuticals. Lactic acid is used in the manufacture of plastics and also in the lacquer industry.

Calcium lactate is a crystalline solid made by the reaction of calcium carbonate or calcium hydroxide with lactic acid produced from whey. Calcium lactate is used in pharmaceuticals and baking powder.

Methyl acrylate, a colorless liquid, has found new uses as a basic chemical in the manufacture of resins, synthetic rubber, and plastics.

A lactic acid lacquer for milk cans has been developed through research carried on by the Bureau of Dairy Industry. The new product is a polymer made from lactic acid and semidrying vegetable such as castor oil or soybean oil. Preliminary results were encouraging. It withstands steam and strong alkali solutions. (34)

Protein Hydrolysates

Protein hydrolysates are protein substances derived from the proteins of skim milk and buttermilk and the albumin in whey. They may be either amino acids or peptones. Peptones are particularly digested proteins containing simple combinations of amino acids. Amino acids are degradation products from proteins.

They are new products developed recently and have found great use due to their nutritional value in medicine and foods. They are used for human and bacterial nutrition, in pharmaceuticals, and as flavoring agents in foods.

In human nutrition, when serious loss of protein has occurred, they are administered intravenously. They are used in extensive wounding, serious burns and in the treatment of pathological conditions. They have been used intravenously in cases where absorption is defective following gastric reaction, cholecystectomy or gastro-enteritis, in the treatment of infants with chronic diarrhea, vomiting, and dehydration in feeding premature babies. They can be used to improve the nutritional state in cases of cirrhosis, intestinal
obstruction, hypothyroidism, nephritis, ulcerative colitis, and cirrhosis of the liver. (35)

Protein hydrolysates may be added to soups, stews, broths, bouillon and bouillon cubes, fish, gravies and scrapple to increase the nutritional value and to add flavoring. One authority on the subject listed 34 foods in which they are used.

In microbiology they are important in the manufacture of penicillin. Peptones are used along with lactose in the mold growth.

Dr. Frank Wang had been doing some experiments with hydrolysates and has fed them to several patients having ulcers as preparation for operation. He was surprised to find the patients became cured without surgery. (36) When fed to 47 control patients, every two hours, some were free from pain in two days, and after three days ulcers no longer showed up on the X-ray films of many of the patients. Many of them gained weight.

Conclusions

Dairy research has concentrated on improving quality and increasing the variety and usefulness of dairy products. Much of this work has been carried on by our own Government and state experiment stations. Research programs carried on by private individuals and companies have also been important. Research in the future will play a great part in the utilization of milk and milk by-products.

Many of the new products and uses for milk in the past several years are now important to the dairy industry in eliminating waste and finding profitable outlets for dairy products. The future use in plastics and medicine will continue to play an important part. Our increased knowledge of the nutritional value of milk has aided materially in the development of new uses for milk and milk by-products.
REFERENCES

1. Borden's Economic Digest, 2; Sept. 1, 1946.


In the preparation of the starter to be used in cheese manufacture, the technique must be similar to that followed in a bacteriological laboratory. The person in charge of the starter laboratory should possess a fundamental knowledge concerning bacteria; what they are, where they come from, how they grow, and how they may be controlled. The mother starter laboratory must be perfectly clean, the operator should wear clean clothes and should have clean hands.

Mother Starter Room

Constructed to:

1. Maintain a uniform temperature, the walls may be insulated.
2. Glass blocks or artificial light used.
3. Air entering the room should be purified. Precipitation of dust particles advisable. Destruction of air-borne bacteria and bacteriophage necessary.
4. The air from the room to be exhausted.
5. The room sprayed occasionally with a germicide.
6. The room used for no other purpose than for the preparation of starter.

Equipment

1. Facilities for convenient sterilization of transfer equipment must be available.
2. Facilities for pasteurization or sterilization of milk and cooling milk in jars or flasks available.
3. Facilities for incubation of the inoculated milk at the exact temperature.
4. Facilities for cooling the coagulated cultures must be available.

5. Facilities for storing the cultures after coagulation at a temperature of 32° to 35° F.

Milk

1. Obtain the milk from a dependable source. The mixed milk from a herd is best. Pay a premium for the milk.

2. Examine the milk regularly for bacteria by means of Methylene blue or Rezasurin test, or agar plate method. Do not use mixed milk obtained from the pasteurizer or the supply tank. The milk may contain inhibitory products not destroyed by heat. It may also contain numerous thermoduric bacteria.

Type of Culture

Cheese starter is a mixture of strains of rapid lactic acid producers of Streptococcus lactis bacteria with the associated organisms either Streptococcus citrovorus or Streptococcus para citrovorus.

Obtain a new culture regularly. When propagated for some time and found active and hardy, discard the oldest culture. Always maintain two cultures.

Pasteurization of Milk for Mother Culture.

The temperature and time held must be high enough to kill nearly all bacterial life in the milk. Boiling does not kill all bacteria. It is necessary to use 250° for 20 to 30 minutes for complete sterilization. This results in browning, obscures the flavor of the starter and makes judging of the starter difficult. Heat containers of milk in boiling water or flowing steam.

1. Use glass top fruit jars or similar satisfactory glass containers. The mouth of the jar and closure must be completely subjected to the heating process.

2. Heat the jars of milk in a tank of water. The tank should be covered.
3. Use a recording or long-stem thermometer in the water.
4. The jars should be 3/4 full of milk.
5. Maintain a temperature of 205°F to 210°F, for 1 to 2 hours.
6. Very slight browning is a good indication of sufficient heating.
7. Cool carefully to 70°F, or to 45°F to 50°F, if the milk is to be held several hours.
8. Keep the milk at 70°F, water temperature for one-half hour before inoculation. Never place the thermometer in the pasteurized milk. Can use jar with water with a thermometer inserted if desired.

**Inoculation**

1. Use a graduated, sterilized glass pipette, or tube for inoculation.
3. Tip open the lid to jar of pasteurized milk.
4. Allow the necessary amount of starter to drain out. If one per cent is used, add 9 ml. per quart, or if 3/4 per cent is used add 6 1/2 ml. per quart. Do not blow into the pipette. Adjust the amount of inoculation to give the correct acidity of the starter at the end of 14 hours.
5. Mix with a rotary motion. Avoid splashing milk into the mouth of the jar.
6. Incubate the milk at 70°F ± 1°F for about 14 hours.

**Acidity of Starter After 14 to 16 Hours Incubation**

1. An acidity of 0.70 - 0.75 per cent results in a large number of bacteria.
2. With higher acidity, fewer bacteria will be present. The older cells die off. Continued over-ripening weakens the organisms.
3. Always make starter daily.
Cooling Starter

1. Arrest the growth of the bacteria and preserve their vitality by cooling the starter to 40°F or below.

2. Place the jars in a tank of clean ice water. Do not shake. Air cooling is unsatisfactory.

Appearance

Good starter should show a smooth curd. At the completion of the incubation period there should be no separation of the whey from the curd. After the cooled starter has been stirred or shaken it should be of the consistency of rich cream. It should be glossy in appearance, not of a dull or chalky luster. The starter should show no large curd particles or lumps, and when poured from the container it should not show aropy condition.

The flavor should be pronounced, yet delicate. Neither a flat flavor nor a sharp acid taste is desired.

Defects in Starter

1. Sharp acid taste - A sharp acid taste is caused by over-ripening the starter. The defect may be prevented by reducing the amount of inoculation and seeing that the temperature during incubation does not exceed 70°F.

2. Bitter taste - A bitter taste may come from using milk that has this taste or from the growth in the milk of bacteria that produce a bitter taste. To prevent this condition, use milk that is free from bitterness, see that the milk is properly pasteurized, avoid contamination of the pasteurized milk with undesirable bacteria, and use only a culture of the desirable types of bacteria for inoculation.

3. Cheesy flavor - A cheesy flavor is caused by the growth in the milk of certain undesirable types of bacteria. To remedy this condition, pasteurize the milk thoroughly, avoid contamination, and use a desirable culture for inoculation. Also, avoid contaminating the finished starter with undesirable bacteria.

4. Metallic flavor - Metallic flavor is caused by over-ripening the starter and keeping it in poorly-tinned containers. The condition can quickly be overcome by using either glass or stainless steel containers for the milk and the finished product, and by avoiding over-ripening.
5. **Flat flavor** - A flat flavor is caused by using milk that contains only a small amount of citric acid or using a culture in which the citric-acid fermenting bacteria are either present in small numbers, or the conditions for the production of flavor compounds are not satisfactory. To improve the flavor use milk from a different source, preferably of a higher solids-not-fat content. It may be desirable to obtain a new culture from a commercial laboratory.

6. **Uncoagulated** - When the starter is uncoagulated at the end of the incubation period, it indicates one or more of the following conditions: (1) the temperature during incubation was too low; (2) the amount used for inoculation was not sufficient; (3) the inoculation material contained relatively few viable bacteria; (4) presence of bacteriophage. To remedy this situation it is necessary to follow the correct methods for making starter and using a culture of bacteria of desirable characteristics.

7. **Gassy starter** - When the starter shows a gassy condition or an undesirable flavor, it suggests one or more of the following conditions: (1) the milk used was not properly pasteurized; (2) the milk was contaminated after pasteurization; (3) unsterilized transfer equipment or other equipment was used; (4) a contaminated culture was used for inoculation. A starter that shows this defect should be immediately discarded, the proper methods for preparing starter should be followed, and a new culture should be obtained.

**Vitality Test**

A vitality test should be made frequently on the different cultures in order to determine which are active and which are inactive.

**Preparing Bulk Starter**

1. Use selected milk.

2. Straight sided, stainless steel cans are satisfactory. Use well-fitting stainless steel covers. Sloping tops are best.

3. Agitator through opening in lid. Tightly fitting.

4. Accurate thermometer in water (an accurate test thermometer should always be available).

5. Thermostat and heater attached. Recording thermometer desirable.
6. Heat to 200°F for one hour.

7. Cool to 70°F.

8. Stir little as this may activate bacteriophage through incorporation of air.

9. Use the necessary amount of milk required for inoculation of each vat. Use one can for each vat.

10. Inoculate the cans with from 3/4 to 1 per cent of active mother starter. May decrease inoculation of the milk for the cans which are to be used last for inoculation of the vats of milk for cheese.

11. Acidity should be 0.70 to 0.75 after 14 to 15 hours incubation at 70°F.

12. Cool with running water. If starter is not to be used until noon it may be cooled to 40°F or below by means of refrigerated water or ice water.

REFERENCES

Hales, M. W., Cultures and Starters, Chr. Hansen's Laboratory, Inc., Milwaukee 14, Wis.


IMPORTANCE OF STARTER IN THE MANUFACTURE OF CHEDDAR CHEESE

Reasons for Using Starter

1. It governs the flavor and the body and texture of the cheese.

2. Through the acid produced it aids rennet action.

3. The acid aids in moisture expulsion.

4. The acid produced influences favorably the changes that take place in the curd during cheddaring.

5. The growth of undesirable bacteria in the curd and cheese is checked.

It is impossible to manufacture Cheddar cheese without the use of a culture of lactic acid producing bacteria. Commercial cultures containing a mixture of selected strains of bacteria are available. Only proven cultures that are hardy and that are satisfactory for Cheddar cheese should be used.

The casein in milk is present in a colloidal form and is known as calcium caseinate. During the coagulation with rennet, the calcium caseinate is changed to calcium para-caseinate. The acid produced from the activity of the bacteria also activates the pepsin of the rennet extract. A certain amount of soluble calcium salt is formed through the action of the lactic acid on di-calcium phosphate in the milk. The soluble calcium salt is necessary for the coagulation of the calcium caseinate in the milk by the rennet enzyme.

The acid produced by the lactic acid bacteria from the milk sugar aids in the expulsion of moisture from the curd particles during cooking and from the curd after the whey has been drained.

The lactic acid aids in the formation of a brine soluble, calcium caseinate from the insoluble calcium caseinate during the cheddaring process. This favors the matting of the curd particles and results in curd of a compact texture.

The acid produced aids in retarding the growth of undesirable types of bacteria in the curd during manufacture and during the ripening of the cheese. The growth of bacteria which cause a putrefactive or protein decomposition and gas formation with the accompanying undesirable flavor is retarded through the action of the acid produced.

Normally one to two billion bacteria per ml. usually are present in good quality starter. If two billion bacteria are present and the milk contains 50,000 bacteria per ml., and if one ml. of starter is added to 100 ml. of milk, there would be present 19,851,485 total bacteria in one ml. mixture of milk and starter.
If the bacteria would double in number every half hour there
would be present after one hour, 79,405,940 total bacteria per ml.
of which 198,020 would be from the milk.

It is important to use milk containing only a few bacteria while
the starter should contain as many active bacteria as possible.

It is advisable to make a test for activity of the starter,
frequently.

Time of Adding Starter

The time of adding the starter to milk is important. Only fresh-
ly made starter should be used. Old starter is generally inactive.
It contains fewer active bacteria than fresh starter. Do not use
high-acid starter. The bacteria in high-acid starter are not in an
actively growing condition. An acidity of about 0.70 to 0.75 per
cent in freshly made starter is considered best for cheese.

Add starter in time so that when the vat is full or ready to set
the starter will have been in the milk the proper length of time. If
for instance, the vat is usually filled and ready to set at 9:00, and
a one-hour ripening time, using 1 per cent starter, is required, add
about 3/4 of the required amount of starter at about 8:10 when the
vat is about 1/4 full. When all the milk has been placed in the vat
add the balance of the starter. It is always better to wait 5 or 10
minutes for ripening and have a uniform ripening time and acidity than
it is for the starter to be in too long.

With fine quality milk, from 1/2 to 3/4 per cent starter is usual-
ly sufficient, while some may use as much as 1 per cent. Too much
starter results in acid flavored cheese. The rule of developing from
0.01 to 0.02 per cent acid above the acidity of the milk before set-
ting may be followed. Experience from day to day will help to serve
as a guide. This increase will generally take place in pasteurized
milk in about one hour.

Bacteriophage

Difficulty has been experienced in Oregon cheese factories with
slow development of acid during the manufacture of cheese. This was
attributed to the presence of bacteriophage. Acid production was
completely stopped about 3 or 4 hours after the addition of rennet.

F. J. Babel at the Iowa Agricultural Experiment Station stated
that very little difficulty was experienced with slow acid production
in the cheese laboratories of Iowa State College prior to November
1944. However, at this time considerable difficulty was encountered
and the principal cause of it was bacteriophage. He, therefore, com-
menced studies on the problem to control bacteriophage. A report was
The summary of the report is as follows:

"Slow acid production, due to the presence of bacteriophage, in
the manufacture of Cheddar cheese usually was apparent at the
time of draining the whey or shortly thereafter.

"The presence of bacteriophage resulted in almost complete ces-
sation of acid production in the manufacture of Cheddar cheese
when either single-strain or multiple-strain cheese cultures
were employed.

"Cheddaring for a long period of time (4 or 5 hrs.) did not re-
sult in an appreciable increase in acidity when acid production
was slow because of bacteriophage action.

"The presence of bacteriophage in bacteria-free filtrates of
whey, culture, starter, etc., could be demonstrated by adding a
small amount of the filtrate to pure cultures of S. lactis
isolated from the culture used in the manufacturing process and
also by the production of bacteriophage plaques on a solid medium.

"When a vat of skim milk intended for cottage cheese was contami-
nated slightly with bacteriophage active against the culture em-
ployed, acid formation was very slow for about 24 hours after
setting. During this same period the bacteria count showed a
slight increase, then a large decrease, and finally a large in-
crease."

The effect of bacteriophage on acid production in the manufacture
of Cheddar cheese was illustrated by the data in the following table:

<table>
<thead>
<tr>
<th>Stage of Manufacture</th>
<th>Bacteriophage Absent</th>
<th>Bacteriophage Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Titrable Acidity %</td>
<td>Titrable Acidity %</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>Milk (pasteurized)</td>
<td>8:00 0.16</td>
<td>8:00 0.16</td>
</tr>
<tr>
<td>Milk plus 1% culture</td>
<td>8:10 0.165</td>
<td>8:10 0.165</td>
</tr>
<tr>
<td>Setting</td>
<td>9:10 0.175</td>
<td>9:10 0.175</td>
</tr>
<tr>
<td>Cutting curd</td>
<td>9:40 0.12</td>
<td>9:40 0.12</td>
</tr>
<tr>
<td>Draining whey</td>
<td>11:10 0.14</td>
<td>11:10 0.13</td>
</tr>
<tr>
<td>Milling curd</td>
<td>1:45 0.52</td>
<td>4:00 0.17</td>
</tr>
</tbody>
</table>
Frequency of Transfer

Starters should be made daily. Recent experiments by A. C. Dahlberg and Fred Ferris clearly show this. In a recent report in Journal of Dairy Science, Vol. 28, Oct. 1945, they stated that "When lactic starters were inoculated every day or every third day and carried under excellent conditions, their quality was identical as judged by appearance, flavor, and acid development. When incubated in milk at temperatures used in cheese making there were slight differences in the starters. When incubated at 86° F, acid development was rapid and the same for both starters; at 100° F, acid development was very slow; and at 86° F, for 2 hours followed by 100° F, for 6 hours the acid development was good and the same for both starters.

"When the freshly coagulated starters were used in cheese making the results were not identical to those secured in milk. The greatest difference was that in the cheese making process the starter transferred every third day gave slower acid development in the curd. When inoculated and set in milk at 100° F, the acid development was almost arrested in the curd and both starters gave comparable results. Cooling the cooked curd back to 86° F did not affect the rate of increase in acid. An initial incubation of the cultures at 86° F in the cheese milk was very important in securing the desired increase of acid in the curd at higher temperatures. Aging starters generally slowed the increases in acidity.

"Cheese manufactured with starters transferred daily developed more flavor of better quality in less time than when made with starters transferred every third day. This was true even though the starters appeared to be of equal quality. The old starters produced unclean flavors in the cheese. However, the cheeses that developed flavor sooner also over-ripened in less time so that they should be put in cold storage earlier to maintain their fine flavor.

"The data show that transfer of lactic cultures every third day as compared with daily transfer reduced the acid produced during the Cheddar cheese making process and incubation at 86° F, in the cheese milk increased the production of acid at the cooking temperature."

Effect of Cooking Temperature on Acid Production By Lactic Acid Bacteria

The cheesemaker must not overcook, as this retards the growth of the starter bacteria. The acid production is slowed up. Recently Golding, Amundson, and Wagenaar, in Journal of Dairy Science, Vol. 28 Oct. 1943, found that a cooking temperature of 102° F. caused a pronounced retardation in the increase of acidity. This has been confirmed by practical observation in cheese factories. One Oregon cheesemaker has reported that by using fine cuts and cooking at 100° F. the starter worked faster and he could set the milk sweeter. This
has considerable significance from the point of view of the ripening of cheese and a production of desirable flavor. If, on the other hand, a large percentage of starter was used, the curd cut coarse (3/8"), and a cooking temperature of 102° or 103° F. was employed it would be easy to "cook ahead" of the acid. This is an undesirable practice. It will result in acid, bitter, poor-bodied cheese. Dr. Babel also studied this problem. He reported in Journal of Dairy Science, Vol. 29, Sept. 1946, that "The rate of acid production of 7 cheese cultures held at temperatures of 86°, 89°, 101°, and 104° F., were determined. Three cultures produced acid more rapidly at 86° F., while 4 cultures produced acid more rapidly at 89° F. All of the cultures produced acid slowly at temperatures of 101° and 104° F."

"The rates of acid production of 7 cheese cultures held continuously for 7 hours at 86° F., were compared with those of the same cultures held 2 hours at 86° F., then 2 hours at 104° F., and then 3 hours at 86° F. Six of the 7 cultures produced less acid as a result of the higher temperature and 1 culture produced slightly more acid.

"In actual cheese-making operations a cooking temperature of 102° F. slightly retarded acid development with 5 of the 7 cultures when compared with a cooking temperature of 100° F. A cooking temperature of 104° F. appreciably retarded acid production as compared with a cooking temperature of 100° F.

"Ripening the milk for a longer period before setting appears to be more time-saving in the manufacture of Cheddar cheese when cooking temperatures of 104° F. are employed than does following the regular procedure and waiting for acid development just prior to milling.

"A slightly high cooking temperature (104° F.) may be an explanation for somewhat retarded acid development in the manufacture of Cheddar cheese, but it does not explain cases of greatly decreased acid production or the actual stopping of acid production by cheese cultures."

Importance of the Starter Bacteria in the Ripening of Cheese.

The starter bacteria are of utmost importance in regulating the ripening of the cheese. However, if bacteriophage is present in the cheese, ripening may be abnormal. Recently, in England, A. A. Nichols and J. Z. Wolf, found that bacteriophage was present in cheese three weeks and 3½ months old when the cheese was made from a starter which contained bacteriophage. The bacteriophage was demonstrated in cheese made in 7 different vats, using three starters in two different localities. In one batch of cheese made from raw milk decimal solutions of the filtered extract showed that after 3½ months ripening bacterio-
A phage was present in quantities of cheese as small as 0.00005 gram (Journal of Dairy Science, Vol. 26, No. 7, 1943, p A-124).

In normal cheese the following changes are among some that occur in Cheddar cheese during ripening:

1. Rapid growth takes place during the first few days of the ripening period. One gram of two or three-day-old cheese may contain several hundred million bacteria. The author found that in a number of samples of one-month-old cheese the counts ranged from 1,673,000 to 20,742,000 per gram. In three-months-old cheese the counts ranged from 1,100,000 to 12,150,000.

2. During the first several months the Streptococcus lactic organisms, chiefly from the starter, are in the majority. Later Lactobacilli and other forms predominate.

3. The lactose present usually disappears in the cheese in from one to two weeks.

4. There is a slow decrease in the percentage of moisture, even in paraffined cheese.

5. There is an increase in total acidity even after the disappearance of lactose as the ripening progresses. Some of this acid combines with calcium and phosphorus to form a soluble salt.

6. The pH is the lowest (most acid) in the cheese about the third or fourth day after pressing. It then increases slowly during the ripening period. A mild, low-acid cheese several days old may have a pH of from 5.1 to 5.3. A medium-acid cheese several days old may have a pH of about 5.0. A distinctly sour or very acid cheese may have a pH of from 4.8 to 4.9.

CLOSE TEXTURE IN CHEDDAR CHEESE

The typical cured Cheddar cheese has a compact texture and a waxy, firm body. The plug of Cheddar cheese should be free from mechanical and gas holes. It should be possible to bend it considerably. When the plug is bent it should be springy and coherent; not short-grained, crumbly, or friable. The break should be flinty. When a piece of the plug is pressed between the fingers it should mold down like molding wax. The body of the cheese must not be weak, pasty, mealy, or greasy. It must not be corky, dry, or rubbery.

When a piece of cheese is placed in the mouth and chewed, it should feel smooth and firm. It must be neither corky nor sticky,
but should be waxy. It should work down slowly and completely without leaving a grainy mixture in the mouth.

Connoisseurs of Cheddar cheese value the desirable close texture and firm, plastic characteristic of well-cured cheese, at a desirable temperature of about 50°F, when it is eaten in the form of pieces or chunks.

U.S. SPECIFICATIONS FOR BODY AND TEXTURE OF CHEDDAR CHEESE

U.S. Grade AA, or U.S. Fancy:

The plug should have the appearance of being solid, compact, and close boring. It may have a few mechanical openings, but no large openings. It shall be free from sweet holes, yeast holes, or gas holes of any kind.

1. Fresh or Current Make - shall be firm, smooth and curdy, or it may be partially broken down if the cheese is over three weeks old.

2. Medium Cured Cheese - shall be firm, smooth and waxy, or it may be slightly curdy or not entirely broken down.

3. Cured or Aged Cheese - shall be firm, smooth and waxy.

U.S. Grade A, or U.S. No. 1

The plug when drawn should have the appearance of being solid and compact, close, or medium close. It may have a few mechanical openings, but these should not be large and connecting. It may have an occasional sweet or Swiss hole, but not more than two on a plug pulled by a regular size cheese trier. It shall be free from other gas or yeast holes.

1. Fresh or Current Make - shall be firm, smooth and curdy, or it may be partially broken down if the cheese is over three weeks old.

2. Medium Cured Cheese - shall be reasonably firm, smooth and waxy, or it may be slightly curdy or not entirely broken down. It may be slightly short or mealy, or slightly weak.

3. Cured or Aged Cheese - may be reasonably firm, smooth and waxy. It may be slightly short or mealy, or slightly weak and pasty.
U.S. Grade B, or U.S. No. 2

May be loose and open. May have numerous sweet holes or scattered gas holes or yeast holes.

1. Fresh or Current Make Cheese - may have a weak body but not to the extent that it is pasty. It may be entirely or partially broken down. A firm, dry, coarse, short, mealy body or a corky body.

2. Medium Cured Cheese - may have a weak pasty body but not to the extent of being soft and smeary. It may have a firm, short, mealy body, or a slightly corky body.

3. Cured or Aged Cheese - may have a weak, pasty body, but not to the extent of being extremely soft and smeary. It may have a firm, short, mealy body.

U.S. Grade C, or U.S. Undergrade

May be loose and open. May have sweet holes, yeast holes, or gas holes.

1. Fresh or Current Make - may be weak and pasty, but not to the extent of being soft and smeary. It may have a firm, coarse, short, mealy body, or a definitely corky body.

2. Medium Cured Cheese - may be weak and pasty, but not to the extent of being extremely soft and smeary. It may have a firm, coarse, short, mealy body, or a slightly corky body.

3. Cured or Aged Cheese - may be weak and pasty, but not to the extent of being extremely soft and smeary. It may have a firm, short, coarse, mealy body.

No Grade Cheese

Weak, to the extent a normal plug cannot be drawn from the cheese.

In these standards the following terms are listed to describe body and texture:

Texture Characteristics

1. Dry and coarse - feels rough, sandy, not smooth.

2. Gas holes - any kind of holes caused by gas fermentation.
3. Large and connecting holes - has the appearance of being loose and open, which is an indication of poor workmanship.

4. Large mechanical openings - so large that they weaken the plug and when taken out of the trier it has a tendency to break apart at the opening.

5. Loose, open cheese - a cheese having mechanical openings the full length of the plug. No solid portions.

6. Mechanical openings - irregular shaped openings which may be few or many, large or small, caused by poor workmanship rather than gas fermentation.

7. Pin holes - so called because the holes are very small and the cheese has the appearance of having been pricked with a pin.

8. Solid and compact - practically free from openings of any kind.

9. Sweet or Swiss holes - spherical openings, glossy in appearance, usually about the size of BB shots; also referred to as shot holes.

10. Yeast holes - slit-like openings, elliptical in shape; often referred to as fish eyes.

Body Characteristics

1. Curdy - young cheese before the curd is broken down.

2. Firm - feels solid, not soft or weak.

3. Pasty - usually weak body. When rubbed between the thumb and finger it becomes sticky and smeary.

4. Reasonably firm - slightly weak, but not to the extent of materially injuring the keeping quality of the cheese.

5. Slightly curdy but not entirely broken down - a plug that is smooth but firm and rubs down curdy, not waxy.

6. Smooth and waxy - free from lumps or hard particles.

7. Soft and smeary - very weak body, very sticky and pasty.

8. Waxy - a cheese that molds well, like wax or cold butter.

9. Weak - requires little pressure to mash, not firm.
Body and Texture Characteristics

1. Broken down - A change in the body from a firm, smooth, or coarse, curdy, or rubbery condition to a waxy condition like cold butter, or to a mealy, or pasty condition.

2. Corky - Dry, coarse, crumbly, and springy. Will not mold together.

3. Mealy - Short body; no elasticity when worked between the thumb and finger, it feels and looks like corn meal. It is not waxy. It does not mold well.

4. Normal plug - Round, same diameter as trier. Should not have the appearance of cottage cheese curd and the body of the cheese should not be so weak that the plug stretches or shrinks from the trier.

5. Short - No elasticity to plug. When rubbed between thumb and finger it tends toward mealiness.

6. Smooth and curdy - Feels silky, not dry; coarse and rough

Meaning of the Term Body and Texture

The dictionary definition of body is "consistency, thickness, substance, strength, as this color has body; or wine of a good body"; and of texture it is "The disposition or manner of union of the particles or smaller constituent parts of the body or substance; fine structure; as the texture of earthy substances or minerals; the texture of a plant or bone; loose or compact texture."

It is somewhat difficult to discuss texture of cheese without making some reference to the body of cheese. The following factors, in general, affect the texture but may, to some extent, affect the body:

1. The Quality of Milk Used

The quality of the milk has a considerable influence on the body and texture of the cheese. If low-grade milk containing numerous undesirable microorganisms is used, gassiness, openness, or weak-pasty body, will result. The cheese may puff. Whether the milk is used raw or is pasteurized it is important to use high-grade milk. If considerable numbers of heat-resistant bacteria are present, the pasteurized milk may contain many of these organisms. Pasteurization is no cure-all. The skim milk used for standardizing should be of a quality equivalent of the whole milk. Use clean sterilized equipment and do not let skim milk remain, for any length of time, at a temperature that favors the growth of microorganisms.
2. Purity of Starter

The starter should contain only active strains of the organism Streptococcus lactis and the associated organism Streptococcus citrovorus, or Streptococcus para citrovorus. The presence of other bacteria, such as gas formers, or yeasts will cause open texture and gas holes in the cheese.

The higher the quality of the milk the greater the need for active starter. Inactive starter used with high quality pasteurized milk result in spongy, weak-bodied, open-textured cheese.

As all the plants of this organization manufacture cheese from pasteurized milk, it is particularly important that only the finest quality starter be used.

3. Efficiency of Pasteurization

Partial or inefficient pasteurization has no place in a cheese factory. The cheese made from improperly pasteurized milk may be gassy and open. Because of the presence of undesirable bacteria in the pasteurized milk, acid development may be rapid and the resultant cheese may show a "short-grained" body and also mealiness. Do not overheat the milk and do not repasteurize milk.

4. Cleanliness of Equipment

Millions of unseen, undesirable bacteria are present on equipment that has not been properly cleaned. Numerous bacteria may be present in milk stone. The bacteria from the uncleaned equipment may cause an undesirable fermentation in the curd and the cheese. Openness due to the production of considerable amounts of gas, such as carbon dioxide gas, may result.

5. Time of Adding Starter and Amount Added

Adding the starter too early and in too large amounts is a sure way to produce cheese that has a mealy body and texture and is also pasty, and weak-bodied. The addition of 3/4 to 1 per cent active starter to the pasteurized milk about one hour before setting is one of the important steps in making cheese that has a close texture and a firm waxy body. If the starter is added too late, or in too small amounts, sufficient lactic acid is not produced in large enough amounts during the cooking process to aid sufficiently in expelling moisture from the curd particles, and the acid production during cheddaring is too slow. The curd will not close up. A certain amount of acid is necessary in order to change the physical characteristics of the curd from a tough, corky condition to a velvety condition,
resembling the appearance of the cooked breast meat of chicken. Furthermore, gas-forming bacteria if present may develop readily in the low acid curd. When acid production is slow because the bacteria are inactive, or if it is completely stopped as the result of the action of bacteriophage, open-textured, spongy, weak-bodied cheese results. The moisture content is apt to be high.

6. Time from Setting to Draining

The production of acid and the expulsion of moisture from the curd particles should be synchronized, so that in about 2 hours and 15 minutes from the time of setting, using pasteurized milk, the acidity of the whey is 0.14 to 0.15 per cent. If the production of acid is too rapid, a mealy-pasty body and texture of the cheese may result. If the production of acid is too slow, a spongy texture, weak body, and probably gas holes will result.

7. Packing and Cheddaring

This is one of the most important steps in the Cheddar cheese making process in regulating the body and texture. The curd should be matted in such a way that whey drainage is facilitated and the temperature kept uniform. Frequent turning of the curd slabs and correct piling is necessary if a close textured cheese of a firm, plastic body is to be obtained. The method of cheddaring as outlined by Mr. H. L. Wilson is very satisfactory. The method is as follows:

As soon as the curd has matted sufficiently, so that it can be turned without breaking it, cut it into slabs 5 or 6 inches wide. The slabs should be turned often, or every 10 or 15 minutes, and on all four sides during the first hour while the curd is warm and tender. This will make all sides smooth and will prevent some of the mechanical openings in the cheese. Always keep the vat covered and when necessary, in order to prevent the curd from cooling too rapidly, admit enough steam into the jacket of the vat each time the slabs are turned to keep the bottom of the vat warm.

1. At the first turning give each slab a 1/4 turn and reverse the ends of every other slab.

2. After 10 or 15 minutes give each slab a half turn. Keep the slabs tight against the wall of the vat and tight against each other.

3. After another 10 or 15 minutes, give each slab a 1/4 turn and place the rough side down.
4. After another 10 or 15 minutes, give all slabs a half turn. If the whey has practically stopped draining and the curd begins to feel dry, the slabs can be piled two deep.

5. After another 15 minutes, separate the slabs and repile two deep, putting the top slab on the bottom.

6. From now on until milling time, separate and repile the slabs two deep every 15 minutes, or often enough to keep the temperature of the curd uniform, and do not allow the temperature to go lower than the temperature at which the curd is to be milled. If the curd is sufficiently firm, the slabs can be piled three or four deep.

Too slow development of acid and allowing the temperature of the curd to decrease several degrees results in open-textured cheese.

Too fast development of acid, and piling too high results in weak, pasty and mealy-bodied cheese.

Control of the temperature of the curd during Cheddaring is very important.

8. Acidity at Milling

When the acidity has developed normally and moisture expulsion has also been normal, the curd will have acquired a desirable close texture. The curd will appear like cooked chicken meat. The acidity, when this condition has been reached, usually in 4½ hours after setting, is about 0.5 per cent calculated at lactic acid.

9. Stirring the Curd After Milling

Careful stirring of the warm curd for some time until the freshly exposed surface of the pieces of curd have "healed" is necessary. Some cooling of the curd takes place.

10. Salting

If salt is added immediately after milling, moisture and fat are quickly drawn to the surface. A coating of fat will remain, resulting in greasy textured cheese and in white lines. The addition of coarse salt in two or three installments evenly applied to the curd, when at a temperature of 85° to 90° F. while stirring is ideal.
11. Hooping

When the curd has regained its silky feel it can be placed in hoops. The temperature must not be allowed to fall below 85° F.

12. Pressing

Pressing should be done carefully. Pressure should be applied gradually until full pressure is applied.

Applying too much pressure at first causes the pressing out of too much fat from the curd. This results in:

a. Excessive loss of fat.
b. Greasy surface of the cheese and of the curd particles.
c. White lines, giving the cheese a mottled appearance.
d. Not cementing the curd particles.

If a hydraulic press equipped with a pressure-controlling device is used it is possible to increase the pressure slowly. Starting with a beginning pressure of five pounds per sq. inch on the water gauge, a pressure of 25 pounds may be reached in about 20 minutes.

After dressing when the cheese is returned to the press use slightly more pressure than was used before dressing. Before the cheesemaker leaves the factory full pressure - 40 pounds for loaves, and 50-60 pounds or more for daisy, triplet, or Cheddar sizes - is applied. It is advisable also to throw several pails of water at a temperature of 130° to 140° F. over the hoops to facilitate the formation of a good rind on the cheese. The cheese should be pressed at full pressure for from 14 to 16 hours. Maintain a temperature of the room of about 70° F.

Defects in Texture

1. Gassy curd. Causes:

a. Using milk that contains gas-producing bacteria. The bacteria may have gained access to the milk from uncleaned, unsterilized utensils, such as milking machines, strainer cloths, pails, cans, etc.
b. Dirty udders.
c. Dirty hands.

Using starter containing gas-producing bacteria. These may have gained access to the starter from:

a. Unsterilized utensils, pipettes, bottles, thermometers, stirrers, etc.
b. Improperly pasteurized milk.
c. Contamination of pasteurized milk used for cheese from equipment, etc.
d. Contamination of pasteurized milk when transferring starter.
e. Using a starter that contains gas-producing bacteria, as when starter is obtained from another factory.

Using unsterilized equipment in the cheese factory - vats, hoops, rakes, press cloths, etc.

Returning unpasteurized whey in milk cans.

How to avoid the defect:

a. Improve the milk supply.
b. Pasteurize the milk efficiently.
c. Use pure starter.
d. Keep all cheese manufacturing equipment in sanitary condition. All equipment should be sterilized with boiling water or steamed before being used.
e. Employ the Curd-Rennet test on milk received from each producer to determine if the milk is in a satisfactory condition for cheese making.

A gassy curd is best handled by:

a. Developing 0.16 to 0.165 acid in the whey at draining.
b. Piling 3, 4, or 5, high during cheddaring.
c. Allowing 0.6 per cent acid to develop before milling.
d. Delaying salting until gas holes have mostly disappeared. The acidity may have increased to 0.8 or 0.9 per cent.
e. Rinse curd with from 5 to 10 gallons of water at 85° to 90° F., depending on the amount of curd.
f. Cure cheese if possible at a temperature of 40° F. or below.

The most common bacteria responsible for the gassy condition of curd and cheese are those belonging to the Escherichia-aerobacter group. They are commonly known as the colon or coliform organisms. They gain entrance to the milk when this is produced under insanitary conditions on the farm. They will grow rapidly in poorly cooled milk. They also gain entrance to the milk when improperly washed and sterilized equipment is used in the cheese factory. Gassy cheese may contain many millions of these organisms per gram.

If the milk contains large numbers of these organisms the control measures given may not be effective even if the starter is very active. If the starter is slow or inactive, control of the gassy condition is impossible.
2. **Greasy Texture**

This is indicated by the presence of free butterfat between the particles of curd. The particles are not properly cemented together as result of:

a. Using very rich milk. High fat to casein ratio; milk frozen or milk two days old.
b. Setting the milk at too high temperature.
c. Cheddaring the curd too long at a high temperature, and piling excessively high.
d. Excessive heating in jacket of vat during cheddaring.
e. Not allowing the curd to cool to 90°F or below before salting.
f. Applying pressure too quickly at the beginning of pressing.

3. **Open Texture**

This is a very objectionable condition. The cheese may crumble when out, and dries out quickly. Retailers object to open-textured Cheddar cheese.

An open texture, other than openings caused by gas-forming bacteria, may be caused by:

a. Insufficient acid production during cheddaring.
b. Allowing curd to become too cold during cheddaring.
c. Not piling normal curd during cheddaring.
d. Curd too cold when placed in press.
e. Insufficient pressing.
f. Curing cheese at a high temperature.

4. **Crumbly Texture**

This may be caused by:

a. Insufficient cheddaring.
b. Cooling curd too much before pressing.
c. Insufficient pressing.
d. Freezing cheese.

5. **Corky body and Texture**

The causes are:

b. Low moisture content of the cheese accompanied with a low acidity in the curd at milling and salting.
c. Over cooking.
d. Over salting.
e. Excessive drying before paraffining.
f. Placing cheese at a temperature of less than 40°F immediately after manufacture.

6. Mealy-pasty body and texture
These two related defects may be caused by:
a. Developing too much acid before the whey has been drained.
b. High moisture in the curd at time of draining the whey.
c. Short period from setting to draining.
d. Cutting curd coarse and not cooking sufficiently.
e. Developing too much acidity in high moisture curd at time of milling.
f. Insufficient salting.
g. High temperature in curing room.

INFLUENCE OF THE PERCENT OXYGEN IN THE HEADSPACE GAS OF CONTAINER ON THE QUALITY OF DRY WHOLE MILK DURING STORAGE FOR ONE YEAR

This report covers one phase of a research project that involved the manufacture, storage and rehydration of dry whole milk. The investigation was conducted by the Department of Dairy Husbandry of the University of Illinois at Urbana, Illinois, in cooperation with the Food and Container Institute for the Armed Forces, Chicago, Ill. Dr. P. H. Tracy, Professor of Dairy Manufactures, was leader of the project. Assisting in the work was Mr. O. M. Schreiter, graduate student.

The method of manufacture consisted of:
a. Heating the standardized milk, which had previously been centrifugally clarified, in a stainless steel pasteurizer in about 45 to 50 minutes to a temperature of 170°F, and holding it at this temperature for 30 minutes;
b. Cooling the milk to 145°F.
c. Condensing in a stainless steel 3-feet diameter vacuum pan to 3 to 1 concentration
d. Homogenizing at 1500 pounds per square inch, first stage and 500 pounds per square inch, second stage, at the temperature as obtained from the vacuum pan.
e. Cooling on a stainless steel surface cooler to about 35°F.
f. Preheating the condensed milk in a 10-gallon capacity stainless steel tank, and finally
g. Spray drying the condensed milk in a 6' x 17' x 9' chamber.
When packing, 155 grams dry milk were weighed into size No. 1 tin containers. The cans were then sealed. A total of 71 packs, usually 24 cans to each pack, was made. When evacuating and gassing, the punctured cans were placed in an evacuation chamber and evacuated and gassed as desired. Immediately after removing the cans from the chamber they were quickly soldered.

The samples of dry milk for all packs were stored for one year at a temperature of 80° to 90° F. At monthly intervals were determined the following:

- Flavor of the reconstituted milk.
- Percent oxygen in the headspace gas of container.
- Percent carbon dioxide in headspace gas of container.
- Solubility index.
- Ascorbic acid content of the freshly reconstituted milk.

Approximately 4000 values were obtained. The following is a summarization of the changes that took place in the values during the one-year storage period.

The values for the 71 packs of dry milk were arranged into five groups in accordance with the oxygen percentage in the headspace gas at equilibrium. These groups were as follows:

- Group 1 - Air Pack (20.8 per cent oxygen).
- Group 2 - 3.04 to 3.50 per cent oxygen.
- Group 3 - 2.00 to 2.84 per cent oxygen.
- Group 4 - 1.04 to 1.96 per cent oxygen.
- Group 5 - 0.27 to 0.97 per cent oxygen.

Change in Per cent Oxygen in Headspace Gas

The oxygen content of the headspace gas decreased gradually during the storage period. Total decrease in the per cent oxygen averaged 3.66 for the air packed samples to 0.66 for the samples packed with the least amount of oxygen.

Change in Per Cent Carbon Dioxide in Headspace Gas

The carbon dioxide values increased during the 12 months from 0 to an average of 0.37 per cent for the air pack samples to 0.15 per cent and 0.14 per cent for the groups packed with the least amount of oxygen.
Solubility Index

An increase in the solubility index was observed for most samples during the storage period. The changes were variable and could not be correlated with the per cent oxygen in the headspace gas.

Increases up to 1.75 in the solubility index took place. With some packs of powder no increase took place during the storage period.

Ascorbic Acid Content of the Dry Milk

The ascorbic acid content gradually decreased during the storage period.

The greatest change took place in the air pack samples. With some of these the ascorbic acid had completely disappeared before the end of the storage period. There was little difference in the average decrease for the four groups of the gas packed powder.

Change in the Flavor Score During Storage

The main purpose of the experiment was to determine the change that took place in sealed containers of dry whole milk packed with different oxygen contents in the headspace gas when stored at 80° to 90°F, for one year.

All powder, whether packed with all air, or with less than 1 per cent oxygen at equilibrium showed decreases in flavor (reconstituted milk was scored) during the storage period. Usually four or five members of the staff of the University of Illinois, Department of Dairy Manufactures, scored the milk. All the samples were known by number only.

The average flavor score of the air packed samples was 10.9 points lower after 12 months than the average of the fresh samples. The gas packed samples showed smaller decreases. The powder packed with the smaller oxygen percentage at equilibrium kept better than that packed with a higher oxygen content. The samples packed with from 3.04 to 3.50 per cent oxygen decreased in average score 4.53 points during the year, and the samples packed with 0.27 to 0.97 per cent oxygen decreased 3.09 points. This was a difference of 1.44 in favor of the dry milk packed with the least amount of oxygen.
The average scores for the five groups were:

<table>
<thead>
<tr>
<th>Group</th>
<th>At Packing</th>
<th>After Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.43</td>
<td>10.53</td>
</tr>
<tr>
<td>2</td>
<td>21.50</td>
<td>16.97</td>
</tr>
<tr>
<td>3</td>
<td>21.28</td>
<td>16.87</td>
</tr>
<tr>
<td>4</td>
<td>21.34</td>
<td>17.81</td>
</tr>
<tr>
<td>5</td>
<td>21.18</td>
<td>18.09</td>
</tr>
</tbody>
</table>

Influence of Particle Size on Keeping Quality

The influence of the dry milk particles on the keeping quality was studied. Eight batches of powder were manufactured. The average size of the milk particles ranged from 8.15 microns in diameter to 19.29 microns in diameter. When the 32 packs of powder were grouped in accordance with the amount of oxygen in the headspace of the container at equilibrium and the decreases in the flavor score were averaged, it was found that the coarser-grained powder possessed a better-keeping quality than the fine-grained powder. For the air-packed samples the coarsest particle powder scored 2.50 points higher than the finest particle powder at the end of the storage period. For the gas-packed samples the coarsest powder scored 0.63 point higher than the finest powder.

CONDENSING WHOLE MILK FOR ICE CREAM MIX
WITH THE VACREATOR

The practicability of using the Vacreator for condensing skim milk for ice cream mix has been demonstrated earlier; (1) the experiments showed that with the "Baby" size machine approximately 500 pounds of water per hour could be removed from the milk, and with the "Junior" size machine approximately 1000 pounds of water per hour could be removed. No tests were made with the larger "M" unit which has a milk pasteurizing capacity three times greater than the "Junior" machine. The method of condensing was found to be practical and simple.

For convenience many ice cream plants would prefer to condense whole milk instead of skim milk if they followed the method of using the Vacreator for the dual purpose of condensing and vacreating. Separation of milk would be an additional operation and some ice cream plants do not have cream separators.
Condensing whole milk with the Vaoreator was found entirely feasible in preliminary tests, but one of the difficulties in using whole milk for condensing is that the fat and solids not fat content of whole milk is variable.

On the other hand, with condensed skim milk when the Baume reading is known the per cent total solids can be calculated (2). If a given per cent total solids in the condensed skim milk is desired, the corresponding Baume reading can also be calculated (3). Because of the lack of a suitable formula it has not been possible to determine the per cent total solids or fat of condensed whole milk when the Baume reading is known, As Hunziker (4) has pointed out, "the pan operator who is striking batches daily knows from experience what the Baume reading of the next batch should be." He suggested that "information is needed as to the correct Baume reading for any desired composition or concentration of the finished product."

The purpose of the present research was:

a. To determine the efficiency of the Vaoreator when used as a condensing unit for whole milk.

b. To determine the relation of the fat and total solids percentages, and Baume reading of condensed whole milk.

c. To develop satisfactory formulae for use in calculating the per cent fat and per cent total solids in unsweetened condensed whole milk when the Baume reading is known.

d. To determine the effect of the process on the number of bacteria in the milk.

After a considerable number of preliminary batches of condensed milk were made, 10 batches of unsweetened condensed milk were prepared from high-testing milk (4 to 5 per cent fat) and 5 batches were made from low-testing milk (3.2 to 3.5 per cent fat). A "Baby" size Vaoreator was used.

The whole milk to be condensed was first placed in a storage vat and was then either pumped through a flash preheater, or a tubular preheater, heating it to 200° F. ± 5°, and then evaporating it under 24 and 28 inches of partial vacuums consecutively in the Vaoreator. The partially condensed whole milk as it emerged from the machine was returned to the storage vat. By continuously circulating it through the Vaoreator, the milk was condensed to the desired ratio of concentration of about 2.1:1 for use in ice cream mix. This condensing ratio is about the same as that used in the manufacture of commercial evaporated milk.
Efficiency of the Vatoreator
When Used as a Condensing Unit for Whole Milk

With a rate of inflow of 5,100 pounds milk per hour 383 pounds water were removed from the milk per hour. With a rate of inflow of 6,300 pounds milk per hour 482 pounds water were removed from the milk per hour.

Relation between the Total Solids Content, Fat Content, and Baume reading of Condensed Whole Milk

The total solids content, fat content, and Baume reading of condensed milk of various concentrations in 10 lots of high-testing milk, and in 5 lots of low-testing milk were determined.

Developing Equations

From the 49 sets of values each of total solids percentages, fat percentages, and Baume readings for the high testing lots of milk, and the 24 sets values each of total solids, fat, and Baume readings for the low testing lots of milk, several equations were developed. They show the relation between the total solids (Y), the fat content (Z), and the Baume reading (X). (E denotes that the value of the variable is estimated by the equation in question.)

The equations for the condensed whole milk made from the high testing milk are as follows:

1. \[ Y_E = 3.2651X - 0.9584 \], with a correlation coefficient of 0.9831 and a standard error of estimate of 0.8262.

2. \[ Z_E = 1.1324X - 0.4193 \], with a correlation coefficient of 0.9450 and a standard error of estimate of 0.5332.

3. The meaning of \( \bar{Z} \) = 34.27 per cent, with a standard deviation of 1.123 per cent.

4. \[ Y_E = 1.5642X + 1.5020Z - 0.3206 \], with a multiple correlation coefficient of 0.9989 and a standard error of 0.2112.

The equations for the condensed whole milk made from the low-testing milk are as follows:

1. \[ Y_E = 2.9356X - 1.5085 \], with a correlation coefficient of 0.9727 and a standard error of estimate of 0.3480.
2. \( Z_F = 0.8687 X - 0.5863 \), with a correlation coefficient of 0.9383 and a standard error of estimate of 0.3875.

3. The meaning of \( \frac{Z}{Y} = 0.2866 \) or 28.66 per cent, with a standard deviation of 1.388 per cent.

4. \( Y_F = 1.3560 X + 1.2429 Z - 0.7802 \), with a multiple correlation coefficient of 0.9816 and a standard error of estimate of 0.5109.

Calculating the Per Cent Total Solids When the Baume Reading is Known

To test the applicability of the equations for determining the per cent total solids in condensed whole milk when the Baume reading is known, 5 batches of condensed milk were made from high-testing milk and 4 batches were made from low-testing milk.

When the equation \( Y_F = 3.2651 X - 0.9584 \) was used for condensed milk obtained from high testing milk, the calculated per cent total solids showed variations from the actual per cent total solids as determined gravimetrically that varied from - 0.84 to 1.13.

When the equation \( Y_F = 2.9356 X + 1.5085 \) was used for condensed milk obtained from low-testing milk, the calculated per cent total solids showed variations from the actual per cent total solids as determined gravimetrically that varied from + 0.32 to + 0.92.

Calculating the Per Cent Total Solids When the Baume Reading and the Fat Test are Known

When the equation \( Y_F = 1.5642 X + 1.5020 Z - 0.3286 \) was used for condensed milk obtained from high testing milk, the calculated per cent total solids showed variations from the actual per cent total solids as determined gravimetrically that varied from - 0.27 to + 0.29.

When the equation \( Y_F = 1.8560 X + 1.2429 Z - 0.7802 \) was used for condensed milk obtained from low-testing milk, the calculated per cent total solids showed variations from the actual per cent total solids as determined gravimetrically that varied from - 0.33 to + 0.41.

Calculating the Per Cent Fat When the Baume Reading is Known

When the equation \( Z_F = 1.1324 X - 0.4193 \) was used for condensed milk obtained from high-testing milk, the calculated per cent fat
showed variation from the actual per cent fat as determined gravimetrically that varied from $-0.47$ to $+0.85$.

When the equation $Z_E = 0.8687X - 0.5863$ was used for condensed milk obtained from low-testing milk, the calculated per cent fat showed variation from the actual per cent fat as determined gravimetrically that varied from $-0.75$ to $+0.64$.

Calculating the Per Cent Fat
When the Per Cent Total Solids is Known

When the equation $Z_E = Y \times 34.27$ per cent was used for condensed milk obtained from high-testing milk, the calculated per cent fat showed variations from the actual per cent fat as determined gravimetrically that varied from $-0.34$ to $+0.44$.

When the equation $Z_E = Y \times 28.66$ per cent was used for condensed milk obtained from low-testing milk, the calculated per cent fat showed variations from the actual per cent fat as determined gravimetrically that varied from $-0.55$ to $+0.21$.

Influence of the Condensing Process
On the Bacteria Present in the Milk

It was found that the bacterial count of the milk in the storage vat dropped rapidly during the first 30 minutes of condensing. The average bacterial count of the milk in the storage vat before condensing was 85,600 per ml. This was reduced to an average of 1480 per ml. at the end of 30 minutes of condensing. The average bacterial count of the condensed milk when leaving the Vacreator at the conclusion of the process was 90 per ml., and the count of the finished condensed product in a storage vat was 200 per ml.

REFERENCES


2. Ibid.

3. Ibid.

THE RECONSTITUTABILITY OF DRY WHOLE MILK

The improvement in the reconstitutability of dry whole milk was listed as the most important of 10 problems involving studies pertaining to the manufacture, analysis and storage of dry whole milk and dry ice cream mix by the steering committee during a technical conference of the dry milk and ice cream mix industry held under the auspices of the Military Planning Division, Research and Development Branch, Subsistence Research and Development Laboratory, Quartermaster Corps, U. S. Army at Chicago, Illinois, January 1945. There was a real need for systematic research on this problem. It was reported by mess officers in the armed forces that considerable difficulty was experienced in preparing reconstituted milk that was free from lumps. It became necessary to instigate research on methods of manufacture of dry whole milk so that the product would reconstitute easily without the use of elaborate equipment. The reconstituted milk should be required to appear like homogenized fresh milk in physical characteristics.

Large amounts of dry whole milk were manufactured during the war years. The United States Department of Agriculture has published the following data showing the amounts of this product manufactured during the period 1935-1946:

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1935</td>
<td>19,432,000</td>
</tr>
<tr>
<td>1936</td>
<td>18,180,000</td>
</tr>
<tr>
<td>1937</td>
<td>15,676,000</td>
</tr>
<tr>
<td>1938</td>
<td>21,496,000</td>
</tr>
<tr>
<td>1939</td>
<td>24,472,000</td>
</tr>
<tr>
<td>1940</td>
<td>29,409,000</td>
</tr>
<tr>
<td>1941</td>
<td>45,627,000</td>
</tr>
<tr>
<td>1942</td>
<td>62,187,000</td>
</tr>
<tr>
<td>1943</td>
<td>187,766,000</td>
</tr>
<tr>
<td>1944</td>
<td>177,786,000</td>
</tr>
<tr>
<td>1945</td>
<td>217,376,000</td>
</tr>
<tr>
<td>1946</td>
<td>188,153,000 (prel.)</td>
</tr>
</tbody>
</table>

The Dairy Manufactures section of the Illinois Agricultural Experiment Station was requested by the Quartermaster General's office to conduct research on the problem. Active experimentation was begun during Fall, 1945. Dr. P. H. Tracy had charge of the work.

This research had for its purpose the development of methods of manufacturing dry whole milk that would reconstitute easily and completely with the use of ordinary cold water without the use of elaborate equipment.

The following is a brief report covering a part of the results obtained. Authorization for presentation was obtained from Doctor Tracy.
Preliminary Studies

The preliminary phase of the work involved the following:

a. A study of various methods of reconstituting, using different mixing devices.

b. The development of a method for evaluating the degree of dispersion of the dry milk in water.

c. The effect of passing the dry milk-water mixture through a homogenizer, on the completeness of the reconstitution.

d. Heating the dry milk-water mixture to 150° F. and then homogenizing.

e. The effect of passing the dry milk-water mixture through a centrifugal clarifier on the dispersion of the dry milk particles.

When reconstituting, the dry milk and water were mixed in the ratio of 14 grams milk to 100 ml. water. For these preliminary tests a mixing time of one-half minute was used. The dry milk was obtained from a batch of condensed milk that had been sprayed at a temperature of 140° F. and at a pressure of 800 pounds per square inch through a No. 72-20 nozzle and using air at a temperature of 325° F. for drying.

A total of 15 different mixing devices was tested in order to determine the ease of and completeness of reconstitution with each mixer. Dry milk was mixed with water at four different temperatures, 40° F., 75° F., 110° F., and 150° F. The use of the mixing methods that produced relatively little agitation, such as with a spoon, a milk stirrer, or a household churn, resulted in poor reconstitution as measured by filtration through a black organdy filter pad having 74 meshes to an inch. Somewhat better results, but not quite satisfactory, were obtained by using hand or electric egg beaters, cream whippers, or a wire whip. An electric malted milk mixer (Stevens) operating at a speed of 9,500 revolutions per minute gave the most satisfactory dispersion of the dry milk in the water. Only occasionally was a small undispersed particle of powder observed on the filter disc when this method was used.

The use of water at 110° F. was most satisfactory. Next was water at 75° F. When 40° F. water was used reconstitution was poor. When 150° F. water was used many of the powder particles formed large, gummy aggregates; considerable foam was also produced.

The addition of the dry milk to the water in the container used for mixing was the most satisfactory of several methods tried of combining dry milk and water when reconstituting.
After considerable experimentation, it was decided to use the following methods for measuring the completeness of reconstitution:

1. Microscopic examination of milk film.
2. Solubility index.
3. Appearance of milk in a one-half filled milk bottle after shaking.

The preliminary research which involved (a) a study of the reconstitutability of spray process dry whole milk composed of different size particles and (b) a study of different methods of reconstituting showed that:

1. A small particle powder dispersed more completely than a large particle powder. A distinct sediment would form in the bottom of the container of reconstituted milk from the large particle powder after a short time.
2. Water at 110°F gave better dispersion than water at 150°F, 75°F or 40°F.
3. Of 15 different mixing devices tested, a high-speed electric malted milk mixer and a portable electric mixer equipped (10 gal. cap.) with a fast revolving propellor were the most satisfactory. With all the other mixers, lumps of varying size would float on the surface of the reconstituted milk.
4. Homogenization of or passing the dry-milk water mixture through a clarifier was effective in dispersing the dry milk particles in the water.
5. Heating the dry milk-water mixture to 150°F then cooling, was practically equivalent to homogenization at a temperature of 75°F and a pressure of 1000 pounds per square inch.

The results from the preliminary research to develop dry whole milk that would reconstitute satisfactorily, using cold water and a simple mixing device can be summarized as follows:

1. Homogenization of the condensed milk at a high pressure (above 2000 pounds per square inch, preferably 3000 to 4000 pounds per square inch) and avoiding overheating in the milk-drying chamber were necessary to obtain reconstituted milk which would have the fat globules uniformly distributed.
2. The addition of sodium citrate, at the rate of 0.2 per cent on the basis of the reconstituted milk, to the water used for reconstituting, had an effect of reducing the number of undispersed particles in the reconstituted milk as determined by the microscopic method which had been developed.

3. The addition of sodium citrate in amounts of 0.20 and 0.60 per cent to the condensed milk before spraying greatly improved the reconstitutability of the dry milk without adversely affecting the flavor. The effect was noticeable both when a large particle and a small particle powder was manufactured.

Having found by experimentation that a number of factors were favorable and a number of factors were detrimental to the reconstitutability of dry whole milk it was decided to prepare condensed milk that would be most desirable, from the point of view of the reconstitutability of the dry milk obtained from it (and considering the physical factor of film and scum). The method of spraying would be varied so as to obtain a fine-particle powder and also a coarse-particle powder. Although the previously made coarse-grained powders did not reconstitute satisfactorily it was felt that, through experimentation, a coarse-particle powder which would possess a good reconstitutability could be manufactured. There are a number of advantages in manufacturing a coarse-particle powder.

The outline of the experiment was as follows:

A. Pre-Drying Treatment

1. Add 0.2 per cent sodium citrate to the standardized milk.
2. Heat the milk to 170°F, and maintain this temperature for 20 minutes.
3. Cool to 140°F.
4. Condense to about one-third the volume.
5. Homogenize the condensed milk at the temperature when removed from the vacuum pan and at a pressure of 4000 pounds, first stage, and 5000 pounds second stage.
6. Cool the condensed milk to about 35°F.

B. Drying

1. Preheat the condensed milk to:
   (a) 100°-120°F.
   (b) 140°F.
2. Use nozzles and cores:
   Number 80-10 (0.0135" diameter orifice; 2 groove core, 0.010" width, 0.018" depth.
   Number 79-16 (0.0145" diameter orifice; 2 groove core, 0.016" width, 0.024" depth.
Number 65-21 (0.035" diameter orifice; 4 groove core, 0.020" width, 0.035" depth.

3. Spray at pressures:
   (a) 3500 to 4000 pounds with small orifice nozzle.
   (b) 800 pounds with large orifice nozzle.

4. Dilute the condensed milk with water before spraying, in one batch, so that it is of the same composition as the milk before it was condensed.

5. Regulate the temperature of the air to the drier so that the temperature of the air leaving the drier is approximately 180° to 190° F., except with one batch reduce the temperature sufficiently to result in dry milk of a higher than normal moisture content.

The manufacturing and analytical data for five batches of dry milk made one day and for two batches made another day from this lot of condensed milk are given in tables 1 and 2.

Tests for Reconstitutability of Powder in Lots 32 and 33
The following tests were used:

1. Solubility index.
2. Visual examination of reconstituted milk in partly filled quart bottles.
3. Examination of defatted film of reconstituted milk by means of a microscope.
4. Determination of the difference in the composition of the top 100 ml. of milk after storage in a filled quart bottle (milk) at 35° F. and the composition of the remainder of the milk in the bottle.
5. Filtration through a black organdy filter disc.

Results

1. Solubility index

When the electric malted milk mixer was used the solubility indexes were 0.05, or slightly less, for all seven batches. Similar indexes were obtained when the hand operated malted milk mixer was used.
2. Visual Examination

The reconstituted milk from all seven batches appeared, after the foam had subsided, like freshly homogenized pasteurized, cooled milk when the electric mixer was used. When the hand operated malted milk mixer was used the reconstituted milk from Lot 32, numbers 1 and 5, showed a slight scum on the surface, but the milk from the other batches appeared like homogenized, pasteurized milk. Even after storage in a refrigerator for 18-24 hours, the physical appearance of the milk was excellent.

3. Microscopic Examination

The dry milk films when examined microscopically showed the complete absence of undispersed particles with the exception of the films of reconstituted milk from Lot 32, number 1 and 5 (electrically mixed), and Lot 32, number 1, hand mixed, which showed a few undispersed particles.

The appearance of these milk films was in remarkable contrast to that of the films of reconstituted milk from most of earlier batches of dry milk manufactured. The improvement was very pronounced.

Methods of Reconstituting

Seven different mixing methods were used with powder composed of small particles and large particles manufactured with and without the use of sodium citrate. On the basis of this test, the mixers would be rated as follows:

- Electric malted milk mixer
- Portable electric mixer equipped with propeller stirrer
- Hand malted milk mixer
- Wire whip
- Egg beater
- Milk bottle
- Milk stirrer and shotgun pail

First
Second
Third
Fourth
Fifth
Sixth
Seventh

Of these mixers, the portable electric mixer of 10 gallon or over capacity would appear to be the most satisfactory to use in army kitchens where electricity is available. The electric stirrer could be used with milk cans, mixing bowls and similar commonly used containers.
## Table 1. Manufacturing and Analytical Data

<table>
<thead>
<tr>
<th>Batch</th>
<th>Sodium citrate added to raw milk before pasteurization</th>
<th>Homogenization pressure for condensed milk, double stage system</th>
<th>Composition of Condensed Milk when Sprayed</th>
<th>Size of spray nozzle</th>
<th>Spraying pressure per square inch</th>
<th>Temp. of condensed milk when sprayed</th>
<th>Temp. of air from drier</th>
<th>Temp. of average size of dry milk particles</th>
<th>Composition of Dry Milk</th>
<th>Solubility index 0.05 or below</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>4000-500</td>
<td>10.318</td>
<td>39.88</td>
<td>1:3.86</td>
<td>79-16</td>
<td>4000</td>
<td>100-118</td>
<td>285-295</td>
<td>182-190</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>4000-500</td>
<td>10.318</td>
<td>39.88</td>
<td>1:3.86</td>
<td>79-16</td>
<td>3300-4000</td>
<td>130-150</td>
<td>270-290</td>
<td>185-190</td>
</tr>
<tr>
<td>3</td>
<td>0.2</td>
<td>4000-500</td>
<td>10.318</td>
<td>39.88</td>
<td>1:3.86</td>
<td>79-16</td>
<td>4000</td>
<td>134-140</td>
<td>270-295</td>
<td>185-187</td>
</tr>
<tr>
<td>4</td>
<td>0.2</td>
<td>4000-500</td>
<td>10.318</td>
<td>39.88</td>
<td>1:3.86</td>
<td>79-16</td>
<td>4000</td>
<td>130-155</td>
<td>295-305</td>
<td>187-192</td>
</tr>
<tr>
<td>5</td>
<td>0.2</td>
<td>4000-500</td>
<td>10.318</td>
<td>39.88</td>
<td>1:3.86</td>
<td>79-16</td>
<td>4000-4500</td>
<td>130-140</td>
<td>215-250</td>
<td>145-165</td>
</tr>
</tbody>
</table>

Solubility index 0.05 or below
<table>
<thead>
<tr>
<th>Batch No.</th>
<th>Per cent of added sodium citrate</th>
<th>Homogenization pressure</th>
<th>Composition of Condensed Milk when sprayed</th>
<th>Size of spray nozzle</th>
<th>Spraying pressure per square inch</th>
<th>Temp. of condensed milk when sprayed</th>
<th>Temp. of air to drier</th>
<th>Temp. of air from drier</th>
<th>Ave. size of milk particles</th>
<th>Composition of Dry Milk</th>
<th>Solubility index 0.05 or below</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>4000-5000</td>
<td>10.318 39.88</td>
<td>1:3.86</td>
<td>80-10</td>
<td>3500-4000</td>
<td>140</td>
<td>235-255</td>
<td>175-190</td>
<td>4.84</td>
<td>24.80</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>4000-5000</td>
<td>10.318 39.88</td>
<td>1:3.86</td>
<td>65-21</td>
<td>800</td>
<td>140</td>
<td>315-330</td>
<td>180-200</td>
<td>21.75</td>
<td>24.51</td>
</tr>
</tbody>
</table>

Solubility index 0.05 or below
STANDARDIZATION OF THE ACIDITY OF CREAM

Reason for Standardizing The Acidity of Sour Cream

1. Control of the flavor of the fresh butter.
2. Control of the amount of fat lost during churning.
3. The manufacture of butter of desirable texture.
4. Control of the keeping quality of the butter.
5. Manufacturing butter of uniform quality from day to day.

When one is considering the value of a vat of cream, the buttermaker has an important task in correctly reducing the acidity of the cream. But much cream in our creameries is not properly standardized. Butter buyers report that much butter has a neutralizer flavor. If 2,300 pounds, 35\% per cent cream, are churned, 1,000 pounds of butter are obtained. At the present this would have a value of $700.00. Unless the job of neutralizing is properly performed, a loss of $10, $20, or more on a churning due to lower quality may be incurred, and in addition, there will be the consumer resistance to poor taste and an abnormal texture of the butter; a loss of one cent a pound on 100,000 pounds means a loss of $1,000.

If 2,300 pounds of cream contains 0.5 per cent acid it will contain a total of 11.5 pounds acid calculated as lactic. If the acidity is to be reduced to 0.15 per cent it is necessary to remove 8 pounds of acid.

Requirements for Correct Acid Standardization

1. Knowing the correct pounds of cream in each vat.
2. Thorough mixing of cream in order to obtain a representative sample. It may be necessary to heat the cream slightly.
3. Removing a sample from the vat for acidity determination.
4. An accurate determination of the acidity of the cream. It is necessary to have available correct strength N/10 NaOH solution for titration. A clean burette, easy to read, should be used and good lighting is essential.
5. A decision on the final acidity or the acidity of the cream before churning.
6. Selection of the proper neutralizer or neutralizers. Don't gamble with poor neutralizers.
7. A knowledge of the proper alkalinity of the neutralizer and ability to calculate correctly the necessary amount of neutralizer to use in order to reduce the acidity of the cream 0.01 per cent in each 100 pounds.

8. Calculation of the amount of dry neutralizer, or the weight or volume of the neutralizer solution to use, is required.

9. Correctly preparing the amount of neutralizer solution of proper strength to add to the vat of cream.

10. The addition to the cream through a distributor of the neutralizer solution.

11. Correctly checking the acidity of the cream after pasteurization and, if necessary, the addition of more neutralizer if the acidity is not reduced sufficiently.

12. Always testing the cream for acidity immediately before churning and enter the results on the manufacturing record.

13. A determination of the pH of the butter serum on all churnings which are to be placed in storage, or which are to be held for one or two months.

14. Always follow the same practice of neutralizing in order to make butter of uniform quality.

Factors to Consider

1. Determination of the amount of cream in the vat.

   It is absolutely essential to know within about 50 pounds, the pounds of cream present in each vat to be standardized. A correctly calibrated metal measuring stick may be used. Measuring is not accurate if the cream contains considerable air or gas. Always measure the cream when it is at the same temperature. One gallon of 35 per cent cream weighs 8.3 pounds at 70° F. A more correct method is to use the weight of the individual lots of cream that were dumped into the vat, plus the amount of water from the steamings of the cans (it is advisable to separate all steaming and rinsing).

2. Determination of the acidity of the cream.

   Use tenth normal alkali solution (N/10 NaOH), that is known to be accurate. It is possible to use a tenth normal acid solution for checking. Ten ml. tenth normal hydrochloric or sulphuric acid will exactly neutralize ten ml. of tenth normal alkali solution. If
preparing tenth normal solution from a concentrated solution, use fresh distilled water, measure accurately.

Obtain a sample which is representative of the whole vat of cream. Tare a dry pyrex glass beaker on a cream balance. Place exactly 9 grams cream in the beaker. With a clean pipette, add 9 grams soft or distilled water. With medium and high acid cream, bring the diluted mixture to a boil in order to eliminate carbon dioxide, which in the form of carbonic acid gas in the cream, would react with alkali. Cool the diluted cream by holding the beaker in cold water for about half a minute. Add four to five drops of phenolphthalein. Add tenth normal alkali while rotating the solution in the beaker until the color is faintly pink and remains pink for a brief time. To facilitate seeing the pink color, place a flat porcelain plate under the beaker. The per cent acid can be read direct on the burette.

3. Neutralizers to use.

There are two general types of neutralizers available - the soda compounds and the lime compounds.

The sodas used in cream neutralization are:

(1) Sodium bicarbonate - NaHCO₃
(2) Sodium carbonate - Na₂CO₃
(3) A mixture of sodium bicarbonate and sodium carbonate

These are relatively mild alkalis. A stronger alkali is a mixture of sodium hydroxide - NaOH - and sodium carbonate - Na₂CO₃, and also straight caustic soda - NaOH.

The limes used in cream acidity standardization are:

(1) Hydrated lime known as calcium hydroxide (Ca(OH)₂).
(2) A mixture of calcium hydroxide and magnesium oxide.
(3) A mixture of calcium oxide, known as quicklime (CaO) and magnesium oxide (MgO).

The neutralizing strength of these limes varies. The first is the mildest and the third is the strongest.

A clean lime should be used. The chemical purity should be high.

Solubility of Neutralizers

Lime is only slightly soluble in water. Calcium hydroxide is soluble in cold water to the extent of 0.185 gram per 100 ml. and in boiling water 0.077 per 100 ml. Quicklime, or calcium oxide, has a
solubility of 0.131 in cold water and 0.07 in hot water at 176° F.

Sodium carbonate Na₂CO₃ is soluble in cold water to the extent of 7.1 grams in 100 ml. and in boiling water to the extent of 45.5 grams.

Sodium bicarbonate NaHCO₃ is soluble in cold water to the extent of 6.9 grams in 100 ml. and 18.4 grams in 100 ml. of water at 140° F.

Sesquicarbonate (Na₂CO₃ • NaHCO₃ • 2H₂O) has a solubility of 13 grams in 100 ml. cold water and 42 grams in 100 ml. boiling water.

When making a neutralizer solution the sodas will be in complete solution at the strength of neutralizer recommended, but the limes will be in suspension. When standing for some time the lime particles will settle to the bottom of the container, leaving a clear layer on top. A suitable tank equipped with a mechanical stirrer is desirable to use if a lime solution is to be kept for some time.

It is possible to prepare a solution that will contain considerable lime in solution in the form of lime sucrate, or "Viscoogen." A product containing about 10 per cent calcium hydroxide in solution when sugar was added was made at Oregon State College.

Neutralizing Strength and Action of Soda and Lime Neutralizers

Lime combines slowly with the acid in the cream and some of it combines physically with the casein. On account of the low solubility of the lime nearly all of the lime is present in the lime mix, in the form of lime particles.

Lime increases the viscosity of cream. When high acid cream is neutralized with lime pronounced thickening of the cream takes place. A scorched or burnt flavor may result when the cream is pasteurized. A mealy texture in the butter will also result and considerable fat may be lost in the buttermilk. Care should, therefore, be taken in not using an excessive amount of lime. As the lactic acid in cream is a weak acid, the reaction between the lime and the acid is slow. More lime than is theoretically sufficient for neutralization, on account of the affinity of casein for lime, is necessary.

Soda is completely soluble in water in the concentration used; it, therefore, combines rapidly with the acid of the cream. This is an advantage in acidity control. While there is much less danger of scorched flavor when soda is used, an excess of soda may cause a soda or soapy flavor. Caustic soda solution when used in high acid cream may give the butter a soapy flavor and a bitey taste, irritating to the tongue. The solution is corrosive to metals. Soda does not cause
a marked thickening of the cream. The texture of the butter is not injured. When the soda neutralizer contains sodium bicarbonate, carbon dioxide is given off, causing the formation of foam on the surface of the cream. The more carbon dioxide that is present in the neutralizer, the greater is the amount of foam. The higher the temperature of the cream the faster is the gas given off. When testing cream for acid when this has been neutralized with sodium bicarbonate it is necessary to first expel the carbon dioxide by heating.

One definite advantage of using soda in neutralization is that at certain seasons in some sections, soda aids in speeding the filtration of the cream.

In considering the neutralizing strength of the neutralizer, it is necessary to know what the neutralizing strength of it is when it is used in cream.

To neutralize one pound of lactic acid in cream when soda is the neutralizer, there will be required:

1. **Sodium bicarbonate** - 0.93 pound for each pound of lactic acid.

   Example of calculation:
   
   90 pounds lactic acid combines with 84 parts sodium bicarbonate.
   
   (Molecular weight of lactic acid = 90)
   
   (Molecular weight of sodium bicarbonate = 84)
   
   \[
   \frac{84}{90} = 0.93
   \]

   Therefore 0.93 pound sodium bicarbonate will neutralize 1.0 pound of lactic acid.

2. **Sodium carbonate** - When technical grade sodium carbonate is used 0.63 pound will neutralize one pound of lactic acid.

3. **Mixture of sodium carbonate and sodium bicarbonate** - When a mixture of sodium carbonate and sodium bicarbonate is used, the neutralizing strength per pound of lactic acid is 0.77 to 0.85 pound, depending on the neutralizer used.

4. **Caustic soda** - Powdered caustic soda has a neutralizing value of 0.44 pound for each pound of lactic acid.

5. **Modified caustic (Special alkali)** - A number of mixtures containing different amounts of caustic soda (NaOH) and sodium carbonate (Na₂CO₃) are available. Thus, one product may contain 90 per cent caustic soda and 10 per cent sodium carbonate. Another product may contain 5 per cent caustic
soda and 95 per cent sodium carbonate.

A mixture which contains 60 per cent caustic and 40 per cent sodium carbonate has a lactic acid neutralizing factor of 0.50. This is considered a very satisfactory neutralizer for high acid cream. There is no foaming and the cream may be filtered. The cream acidity may be reduced to 0.40 per cent with this neutralizer and then with a milder alkali to the desired acidity.

Note: Caustic soda is corrosive to metals such as copper, tin, and zinc. It forms soap with fat. Caustic soda will burn the skin and clothes, particularly wool. It must be used with care when neutralizing.

In the event of contact of caustic soda with the body, apply plenty of cold water; then apply a 10 per cent solution of boric or citric acid. For lip or eye burn, apply a 2 per cent solution of boric or citric acid.

6. Lime - When lime is used as a neutralizer the following amounts are necessary for each pound of lactic acid in the cream:

a. Calcium hydroxide 0.5 pound
b. Mixture of calcium hydroxide and magnesium oxide: 0.38 pound (example)
  c. Calcium oxide and magnesium oxide: 0.3 pound (example)

Manufacturers and dealers will give information regarding the neutralizing value of the neutralizer supplied when used for cream.

How to Use Neutralizers

In a small or medium sized creamery, it is most convenient to weigh out the neutralizer necessary for each vat of cream. In a large plant, a stock solution may be prepared. The required amount of this stock solution is then diluted before it is added to the cream.

It is convenient to prepare a table showing the amount of dry neutralizer required for a wide range of acidities for reduction to any desired per cent of acidity. It is necessary to know the amount of dry neutralizer that is necessary for each 0.01 per cent acid in 100 pounds cream. For example, if the acidity is to be reduced from 0.60 to 0.30 per cent, the table will show the pounds neutralizer calculated to the nearest tenth pound, necessary for reducing the acidity in quantities of cream ranging from 100 pounds to 3,500 pounds or more with intervals of 50 pounds.
Example of Calculation using Lime

Assume a neutralizing value of lime: 0.003 pound for 0.01 percent acid in 100 pounds cream. If the acidity is to be reduced from 0.75 to 0.45, use $30 \times 0.003 = 0.090$ pound.

If 2,300 pounds cream are to be neutralized use $0.09 \times 23 = 2.1$ pounds lime.

The lime should be weighed out on a scale which is accurate to 0.1 pound. It should then be mixed thoroughly with from 10 to 15 times its weight of warm water, or sufficient to make 3 or 4 gallons of solution for a 2,300 pound lot of cream.

If this particular lime were to be used for making a stock solution of lime neutralizer, this may be made up so that each pound or pint of solution will neutralize a definite amount of lactic acid in the cream.

If it is desired that one pint of the lime solution shall neutralize a half pound lactic acid, the solution must be made up as follows:

If 0.3 pound lime = 1 pound lactic acid and
0.15 pound lime = \frac{1}{2} pound lactic acid.

Therefore, each pint of solution must contain 0.15 pound lime.
If 10 gallons of solution is to be prepared use $10 \times 0.0 \times 0.15 = 12.00$ pounds lime.

Add the lime to a 10-gallon crock and add warm water while stirring until the solution reaches the 10-gallon mark.

If 2,300 pounds of cream are to be neutralized from 0.75 to 0.45 percent, the amount of lime solution to use is:

\[
\frac{0.75 - 0.45}{0.30} = 0.30 \text{ per cent acid to be neutralized.}
\]

\[
\frac{2300 \times 0.30}{100} = 6.9 \text{ pounds acid to be neutralized.}
\]

\[
6.9 \times 2 = 13.8 \text{ pints of solution}
\]

Before this solution is to be added to the cream it should be diluted with water to give approximately 3 to 4 gallons.

Proof of Accuracy of Calculation

0.15 pound lime in 1 pint
0.15 x 13.8 = 2.1 pounds dry lime.

A table that shows the pints of lime to use for different acidities and for varying amounts of cream can easily be prepared.
Be sure to stir the lime solution thoroughly before measuring the amount to use. A mechanical agitator is desirable. Keep the container well covered and clean it thoroughly when a new batch is to be made up.

**Example of Calculation Using Soda**

Assume that the neutralizing value of the soda used is: 0.008 pound soda for each 0.01 per cent acid in 100 pounds of cream. If the acidity is to be reduced from 0.45 to 0.15 per cent use $30 \times 0.008 = 0.24$ pound.

If 2,300 pounds of cream are to be neutralized, use $0.24 \times 23 = 5.52$ pounds of soda.

Convenient tables that show the amount of soda to add to batches of cream varying from 100 pounds to 3,500 pounds for different acidity reductions can easily be prepared, if the neutralizing value of the soda is known.

The soda used should be weighed on an accurate scale. The soda should be thoroughly dissolved in 3 to 4 gallons of warm water.

**Using Two Neutralizers**

With cream that exceeds 0.65 per cent acid, it is advisable to first neutralize it with lime and then with soda.

If lime is used as the sole neutralizer with high acid cream, thickening of the cream takes place; a scorched, neutralizer flavor may be produced during pasteurization. The butter may be mealy. Because so much lime was used the butter may have a pronounced limey flavor.

If soda is the only neutralizer, a definite soda or soapy flavor may be present in the butter. The soda, however, causes no thickening of the cream. If the soda neutralizer is a mixture of sodium carbonate and sodium bicarbonate, or if it is all sodium bicarbonate, a considerable amount of carbon dioxide will be given off after the soda solution has been added to the warm cream. This results in so much foam that some of this may be lost due to overflowing. This is a definite disadvantage of the use of bicarbonate. The amount of carbon dioxide liberated from the cream can be reduced if the soda is dissolved in hot water.

The practice of using two neutralizers with high acid cream is well established and is generally practiced. Some buttermakers neutralize down to 0.45 or 0.50 per cent with lime and then with soda.
to the desired acidity. Others follow the practice of neutralizing with lime 1/3 of the acidity to be reduced and the other 2/3 of the acidity with soda.

Some creameries prefer to use a special alkali containing caustic soda and sodium carbonate as the sole neutralizer for high acid cream.

The value of using sodium bicarbonate with the object of removing undesirable flavor in the foam has been greatly over estimated.

Serum Acidity

The acid in the cream is for the most part present in the fat-free part of the cream known as the serum.

Theoretically, acidity reduction should be based on the acid present in the serum. By serum is understood the fat-free portion of the cream.

If two vats of cream, 2,300 pounds each, one testing 30 per cent fat and the other 40 per cent fat, each contains 0.75 per cent acid, what is the per cent acid present in the serum of each vat of cream? Example:

(a) Low-fat cream
2,300 x .30 = 690 pounds fat
2,300 - 690 = 1610 pounds serum
2,300 x .0075 = 17.25 pounds acid
\[ \frac{17.25 \times 100}{1610} = 1.07 \text{ per cent acid in serum} \]

(b) High-fat cream
2,300 x .40 = 920 pounds fat
2,300 - 920 = 1380 pounds serum
2,300 x .0075 = 17.25 pounds acid
\[ \frac{17.25 \times 100}{1380} = 1.25 \text{ per cent acid in serum} \]

Assuming that the acidity of both vats of cream is reduced to 0.20 per cent. What would be the serum acidity of each vat of cream?

(a) Low-fat cream
2,300 x .002 = 4.6 pounds acid
\[ \frac{4.6 \times 100}{1610} = 0.28 \text{ per cent acid in serum} \]

(b) High-fat cream
2,300 x .002 = 4.6 pounds acid
\[ \frac{4.6 \times 100}{1380} = 0.33 \text{ per cent acid in serum} \]
It would be desirable to have the serum acidities of the neutralized cream the same in order to obtain butter that has a pH that is similar.

If the serum acidity of the 30 per cent cream is taken as the desired acidity to which to neutralize, the cream acidity is 0.20 per cent, and the serum acidity is 0.28 per cent, what should be the final acidity of the 40 per cent cream in order to obtain the same serum acidity? Example:

\[
100 - 40 = 60 \text{ per cent serum in 40 per cent cream} \\
60 \times 0.28 = 0.17 \text{ per cent acid in 40 per cent cream.}
\]

Amount of Acid Reduction

The acidity should be reduced sufficiently so that:

a. The flavor of the fresh butter is satisfactory.
b. The loss of fat during churning will be at a minimum.
c. The butter is not mealy.
d. The butter can be safely stored, if necessary, for an extended time.

The buttermaker is depending on the acidity test to regulate the acidity of the butter serum. It is necessary, however, that the acidity of the cream at churning should be such that the reaction of the butter serum, spoken of in terms of the hydrogen ion concentration and as indicated by the "pH" is neither too high nor too low. A pH of 7.0 is neutral. A higher pH than 7.0 is alkaline and a pH below 7.0 is acid.

If the pH of the butter serum is too low (too high acid), the flavor of the butter may be "coarse-acid" and if such butter is stored an undesirable oily flavor and even a fishy flavor may develop in salted butter stored at a low temperature. The development of these defects is favored by exposure of the pasteurized cream to copper or iron.

On the other hand, if the pH is too high (alkaline) the butter may have a neutralizer flavor. When stored, a tallowy flavor caused by oxidation, may develop. Mealiness in the butter may be caused by over-neutralization of high acid cream with lime, and if the neutralizer used contains caustic soda, a soapy and bitey flavor may be present.

Correct neutralization to an acidity slightly above the neutral point, as measured by the titration method, using N/10 NaOH and phenolphthalein, eliminates coarse-acid flavor, but if the cream is neutral-
ized to a point that will result in butter with a serum pH of 7.0 (neutral), the flavor will be flat, or insipid. The ideal method to use when the butter is to be retailed shortly after manufacture, would be to neutralize medium or low-acid cream to about 0.13 - 0.15 per cent acid and high acid cream to about 0.17 or 0.18 per cent acid, and adding about 5 per cent of fine-flavored starter, either after the cream has been cooled or just before churning. If starter is not used, neutralize to a slightly higher acidity, about 0.02 to 0.03 higher. Avoid neutralizer flavor. This cannot be covered up by starter. The addition of artificial butter flavor is prohibited by federal regulations.

The serum pH of the butter made from such cream will range from 6.6 to 6.9. If the butter is to be stored for several months, neutralization to an acidity that will give a pH of the butter serum which is neutral (7.0 ± 0.1) has been found most satisfactory in order to preserve the original flavor of the butter and avoid storage defects.

**Laboratory Tests**

If to an acid solution is added an alkali such as sodium hydroxide, using phenolphthalein as an indicator until a slight pink color is produced, the solution will have a pH of 8.3. As 7.0 pH is the neutral point the solution is, therefore, alkaline. If cream is neutralized so that the acidity is zero by the acid test using phenolphthalein as an indicator, the cream will, therefore, be alkaline.

Unless the serum of the butter is checked for pH it is a problem for the buttermaker to know if the neutralization of the cream has been correct. A dependable method of determining the reaction of the butter serum is by means of a pH meter. It is not recommended that every creamery should use this method of checking. For standardization purpose, however, the pH of the serum of butter sent to a central marketing organization should be determined and the results should be sent to each creamery.

Considerable variation in the pH of the butter serum in the butter sent to the Oregon State College monthly educational butter scoring and analysis service has been observed. During the 13th year of this service, 584 churnings of butter showed the following pH values of the butter serum:
Such a variation shows a definite lack of sufficient attention to the important work of cream acidity standardization. A continuous laboratory service and a study of accurate butter manufacturing reports, together with the butter grading reports, would enable the laboratory technician or technologist in charge to suggest to the various buttermakers methods for improvement of neutralizing technic when abnormal pH values are encountered.

This matter should, of course, not be over-emphasized as there are a number of factors, in addition to that of acidity control, that have a pronounced effect on the quality of the butter and the storage property.

Any creamery that stores a considerable amount of butter and any buyer of butter, intended for storage, should ascertain the pH value of the butter serum of each lot of butter. If the pH values vary too much from the standard, the economic risk will be great. No creamery, marketing organization, or butter dealer who stores a considerable amount of butter, can afford the risk of storing butter that is likely to become oily-fishy, or oxidized-tallowy during storage.

Summary of Method of Acidity Standardization
Using Lime and Soda

1. Accurately weigh the amount of each neutralizer to use. Dilute with 10 to 15 times the weight of warm water. Mix well. Allow lime mix to stand 10 minutes before using. The soda dissolves readily.

2. Prepare the cream in the vat by agitating it and heating it to 70° - 80° F. Be sure it is free from lumps and that no unmixed heavy cream remains in the bottom of the vat. Stir with a hand stirrer or metal paddle, if necessary.

3. Place the prepared lime neutralizer in an elevated metal can, the bottom of which is connected with a perforated, sanitary pipe, inserted below the surface of the cream, and add it slowly (in about 5 minutes) to the cream in the vat. Keep the cream stirred.
4. After 15 minutes add the soda solution in the same manner. Be sure all the soda is dissolved.

5. Add no sour cream after the neutralization process has been commenced. Sweet cream may be added directly after neutralization and before pasteurization.

6. Pasteurization can be commenced five minutes after the soda solution has been added.

7. Sweet cream lowering acidity in vat does not constitute neutralization; the sour cream must first be neutralized.

Causes of Over-Neutralization of the Cream
1. Less cream in the vat than calculated.
2. Using more than the required amount of cream for the acid test.
3. Using a weak alkaline solution when determining the acidity.
4. Using incorrect strength neutralizer (too strong).
5. Using too much neutralizer - improper calculation and weighing.
6. Not boiling sour cream containing carbon dioxide for the acidity test.

Causes of Under-Neutralization of the Cream
1. More cream in the vat than calculated.
2. Using less than the required amount of cream for the acid test.
3. Using a strong alkaline solution when determining the acidity.
4. Using incorrect strength neutralizer (too weak).
5. Using too little neutralizer - improper calculation when weighing.

Causes of Neutralizer Flavor
1. Improper acidity determination (too high acidity reading obtained).
2. Adding neutralizer to cold, heavy and lumpy cream.
3. Cold, heavy cream in bottom of vat.

4. Too concentrated neutralizer solution.

5. Lumpy neutralizer or too much lime neutralizer, or using caustic neutralizer. A soapy flavor may be produced if too much soda neutralizer is used.


7. Improper addition of neutralizer to cream.
   a. Adding it too fast.
   b. Adding it to one end of the vat.
   c. Not spraying it into the cream.

8. Adding more neutralizer than calculated (my mistake or incorrect weighing of neutralizer).

9. Incorrect calculation of the amount of neutralizer.

10. Less cream in the vat than calculated.

11. Reducing acidity below standard (appreciably above normal pH of the butter serum).

12. Adding neutralizer to the cream before all the sour cream has been added.

Prevention of Neutralizer Flavor

1. Have the cream in a homogeneous condition.

2. Heat the cream slightly if it is cold and thick.

3. Use a milk neutralizer with cream of medium or low acidity.

4. Use two neutralizers, lime and soda, with high acid cream.

5. Add the correct amount of well-diluted neutralizer solution to the cream.

6. Spray the solution slowly into the cream while it is being stirred.

7. Add sufficient neutralizer so that the butter serum will have a pH from 6.6 to 7.0 depending on whether the butter is to be consumed soon or is to be held in storage.
Causes of Scorched - Acid Flavor

Among the causes of this flavor can be mentioned:

1. Under-neutralization.
2. Adding small amounts of sour cream to sweet cream in a vat without first neutralizing the sour cream.
3. Adding sour cream to neutralized cream.
4. Adding sour cream to pasteurized cream.
5. Adding high-acid starter to pasteurized cream, or using too much starter.

Causes of Scorched - Neutralizer Flavor

One of the causes of this defect is heating the cream to too high a temperature, in a coil vat, especially when the cream has been neutralized to a low point with lime.

To avoid this defect it is necessary to first heat thick, lumpy cream to about 70° to 80° before neutralization. Add the neutralizer slowly and evenly. After the cream has been properly neutralized it may be heated to the pasteurization temperature. Do not employ an excessively high temperature for the heating medium, especially when heating cream which has been thickened by lime. The heating surface should be free from a deposit of minerals and other milk solids. With the coil vat method, a scorched-neutralizer flavor can usually be avoided if the cream is carefully heated to 165° or 168° F. With cream of medium acidity, properly neutralized, a slightly higher temperature such as 160° or 162° F. may be used. It is necessary that the inside heating surface is free from a deposit of minerals.

Cause of Mealy Texture of Butter From Neutralized Cream

1. This undesirable defect will be present in butter when the cream either has been under-neutralized or over-neutralized. If the cream was under-neutralized, extensive hardening of the casein takes place. The particles of casein become embedded in the butterfat.

2. When the cream, especially high-acid cream, has been over-neutralized with lime, because of the affinity of casein for calcium, large aggregate particles of casein and lime are formed. These also will become embedded in the butterfat. The butter will be pronouncedly mealy or grainy.
Neutralizing a Mixture of Sweet and Sour Cream

When a considerable amount of sweet cream is to be mixed with sour cream in the vat it is desirable to neutralize the sour cream first. If this is not done, the butter may have a sour or vinegary flavor, and if curdling takes place during pasteurization mealy textured butter will result.

Supposing 2,000 pounds of sweet cream with an acidity of 0.13 per cent and 500 pounds of sour cream with an acidity of 0.40 per cent are mixed. The acidity of the mixture theoretically would be 0.184 per cent. Ordinarily cream of this acidity would not need to be neutralized. However, the flavor of the sour cream added would have a pronounced influence on the flavor of the butter. The criticism of the finished butter will be coarse-acid or sour flavor.

It is advisable to always neutralize the sour cream before it is mixed with the sweet cream. A better plan is, of course, to pasteurize and churn the sweet and the neutralized sour cream separately.

Correction of Over-Neutralization

Occasionally a vat of cream is over-neutralized because of an error in calculating the amount of neutralizer. There is little that can be done to overcome the damage. The butter will invariably have a neutralizer flavor and if lime was used for neutralization the butter will undoubtedly be mealy.

If some fine-flavored starter, or some cultured buttermilk is available, the addition of two or three cans of these to the vat of cream would have a beneficial effect and it would be possible to obtain butter of nearly the desired pH value.

Problem:

It is desired to churn cream of an acidity of 0.20 per cent. If 5 per cent starter is used and the acidity of the cream is not increased during the holding period of the cream until churning, how low should the cream be neutralized?

Reduce to 0.17 per cent acid so that the acidity of the cream immediately after the addition of the starter is 0.20 per cent. Cool the cream before the starter is added to a temperature of 40°F. If the cream is to be cooled to only 50°F, as during the fall and winter months add the starter shortly before churning.
Relation of Titratable Acidity of Cream to pH of Butter Serum

The buttermaker is interested in manufacturing the finest flavored butter possible from the cream that is available. He is also interested in manufacturing the butter in such a way that it will not show appreciable deterioration in quality either during short-time or long-time storage.

Research at several state experiment stations and in commercial plants has definitely shown that butter which shows a low pH of the serum keeps poorly, even in cold storage at zero degree F. The most common and objectionable defect which develops is a fishy flavor. Fishiness in salted butter can be controlled by keeping metallic contamination to a minimum and by so regulating the acidity of the cream at churning that the pH of the butter serum ranges from 6.6 to 7.0. Control laboratories can assist the buttermakers in their effort to maintain a correct pH of the butter serum. Hussong, in discussing the significance of the measurement of the pH of butter stated that: "The experience of three storage periods has confirmed the value of using pH as a means of controlling keeping quality. This season the pH of all butter scheduled for storage was determined and those churnings falling outside the desired range were not stored. The results of the procedure to date have been very satisfactory. In previous years those churnings which developed a fishy flavor showed pH values below the desired limit and confirmed observations made in the laboratory. The pH found to be most useful under the conditions studied was 7.0 ± 0.2 and it seems likely that the butter with pH values near the top of the range possessed better keeping quality than that in the lower range."

Unless the buttermaker has a pH meter it is difficult for him to determine what should be the titratable acidity of the cream at churning. The results from research, abstracted below, by White (Department of Agriculture, Ottawa, Canada, published in the Canadian Dairy and Ice Cream Journal, Vol. 26, June 1947) will serve as a guide to buttermakers in connection with cream acidity and butter serum control.

"When churnings with pH of 6.7 to 6.9 and 6.91 to 7.2 are grouped according to the original acidity of the cream, see table, the data show that as the original acidity of the cream increased the actual titratable acidities and the calculated acidity at the churn increased accordingly. For cream of approximately 0.26 per cent acidity, the calculated acidity at the churn was slightly less than 0.12 per cent for a pH of 6.79, while for creams between 0.51 and 0.6 per cent acid with an average initial acidity of 0.56 per cent, the calculated acidity after pasteurization was nearly 0.15 per cent. For butters with an average pH of about 7.0, the average acidities
after neutralization were lower than for butters with an average pH of about 6.8"

Average Acidities of Creams for Butters within a Definite pH Range

<table>
<thead>
<tr>
<th>Acidity Range %</th>
<th>No. of Samples</th>
<th>Initial Acid %</th>
<th>Desired Acid %</th>
<th>At Churn Acid %</th>
<th>Calculated pH of Butter</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH Range 6.7 - 6.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.2 - .3</td>
<td>9</td>
<td>.255</td>
<td>.123</td>
<td>.148</td>
<td>.118</td>
</tr>
<tr>
<td>.31 - .4</td>
<td>28</td>
<td>.347</td>
<td>.122</td>
<td>.149</td>
<td>.122</td>
</tr>
<tr>
<td>.41 - .5</td>
<td>13</td>
<td>.454</td>
<td>.140</td>
<td>.170</td>
<td>.128</td>
</tr>
<tr>
<td>.51 - .6</td>
<td>10</td>
<td>.560</td>
<td>.148</td>
<td>.176</td>
<td>.148</td>
</tr>
<tr>
<td>.61 - .7</td>
<td>2</td>
<td>.645</td>
<td>.160</td>
<td>.205</td>
<td>.165</td>
</tr>
<tr>
<td>pH Range 6.9 - 7.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.2 - .30</td>
<td>11</td>
<td>.260</td>
<td>.106</td>
<td>.128</td>
<td>.113</td>
</tr>
<tr>
<td>.31 - .40</td>
<td>16</td>
<td>.354</td>
<td>.116</td>
<td>.138</td>
<td>.107</td>
</tr>
<tr>
<td>.41 - .50</td>
<td>18</td>
<td>.454</td>
<td>.133</td>
<td>.158</td>
<td>.112</td>
</tr>
<tr>
<td>.51 - .60</td>
<td>9</td>
<td>.564</td>
<td>.148</td>
<td>.150</td>
<td>.112</td>
</tr>
</tbody>
</table>

The calculated acidities at churning time were determined by calculating the quantity of acid which would be theoretically neutralized by the quantity of neutralizer used as shown on the report forms, and subtracting this figure from the total pounds of acid in the cream. The resulting figure represented the pounds of acid which remained in the cream, and with the pounds of cream known, the per cent acidity was readily calculated.

On the basis of the data obtained it was concluded that "the neutralizing data of the commercial and semi-commercial churnings used in this study, indicate that a uniform pH value can be maintained in the butter without too much difficulty. To obtain uniformity however, it is necessary to adjust the desired acidity at the churn according to the initial acidity of the cream, and to carry out the details of various steps in the neutralizing procedure carefully and accurately.

"The acidities of vats of cream during any particular season will not vary a great deal under average conditions in Canadian creameries, so that only slight adjustments in the desired acidity will be necessary. To obtain a pH of approximately 6.8 in the butter, the
data indicate that cream with an initial acidity of 0.25 to 0.3 per cent should be reduced to 0.11 or 0.12 per cent acid. When the initial acidity is 0.4 to 0.5 per cent, the desired acidity at the churn should be 0.13 to 0.14 per cent. In general, for each increase of 0.10 per cent in the initial acidity of the cream the desired acidity should be increased by 0.01 per cent. One creamery used this method of adjusting the acidity at the churn with very satisfactory results.

"However, with soda-type neutralizers and vat pasteurization, the titratable acidity at the churn will be somewhat higher than the desired or calculated acidity due to the evolution and retention of carbon dioxide in the cream during the neutralizing reaction. For cream with an initial acidity of 0.4 to 0.5 per cent, this increase will be approximately 0.03 or 0.04 per cent, but in some instances may be more. The difference between the titratable acidity and the desired or calculated acidity should be determined for the conditions in each plant. As shown in these studies and by Dunkley and Wood, these differences will vary with the initial acidity of the cream, with the type and fullness of the vat, and probably to some extent with the type of soda neutralizer used.

"Under the neutralizing and pasteurizing conditions at the Dairy School, Kemptville, the results of the acidity tests on boiled samples agreed very closely with the desired or calculated acidity. The titratable acidity of a boiled sample would, thus, appear to be a good check on the accuracy of the neutralizing process under usual plant conditions.

"If the neutralizing procedure is done carefully and accurately, and the acidity is reduced to a level which will give a pH of 6.8 to 7.0 in the butter serum, too much attention need not be given to the titratable acidity at the churn. It is a wise precaution, however, to keep a record of the titratable acidity at the churn and thus have a day-to-day check on the neutralizing process."
THE FLAVOR OF MILK

Production of milk during 1946

By cows on farms 119,730,000,000 lb.
Civilian consumption of fluid milk and cream 59,000,000,000 lb.

This is about one-half (49.3%) of all the milk produced. The annual per capita consumption of fluid milk was 425 pounds.

This should be added to the 2,389,000,000 pounds evaporated milk which represents approximately 4,389,000,000 pounds of fluid milk. The balance of the milk produced was used for the manufacture of dairy products with a small amount used as a feed for calves.

From a human welfare point of view there is no more important activity than that of supplying the American people with clean, wholesome, fine flavored milk. The producers of milk, the transporters of milk, the processors, and the distributors have a tremendous obligation in furnishing the consumers—babies, growing children, and adults—with this, nature's most important and almost perfect food.

The requirements for milk of excellent quality are:

1. It must be obtained from healthy cows, properly kept and fed. The persons handling the milk must be healthy.

2. The cows, barn, milk house, milking utensils, etc., must be clean so that the milk will not contain any foreign matter.

3. Such precautions must be taken during the production that the milk is not contaminated with bacteria, dust, insects, or foreign matter of any kind.

4. The milk should be cooled quickly after it has been obtained from the cow to a low enough temperature to check bacterial growth. It should be stored in odor-free, clean, well-tinned sterilized cans and protected from odors and dust until it is shipped to the milk plant.

5. While cans of milk stand at the roadside, they should be protected against sun, dust, rain and mud, and the cans should be protected against dust and sun during transportation to the milk plant.

6. Processing and bottling by healthy persons in a sanitary plant.

Proper grading at the milk plant or receiving station includes grading for flavor. By flavor is understood a combination of the
taste and odor of a substance. There are only four primary tastes, namely, sweet, acid, bitter and salty. They are determined chiefly by the taste buds located on the tongue, soft palate, and larynx. The sweet taste is primarily determined with the tip of the tongue, the bitter with the rear, the acid with the sides, and the salt with the upper surface of the tongue. Dry substances cannot be tasted. They must be in a liquid or semi-liquid form. Very infinitesimal substances are responsible for the odor. They are determined by the organs of smell. Some of them can be observed by smelling the food before it is placed in the mouth while others are observed when the food is being masticated and swallowed.

A milk grader cannot smell a salty or a bitter taste in milk. He must place the sample of milk in the mouth. If the milk has an acid taste, it may also have an undesirable odor. The bacteria which were responsible for the production of acid may also cause the production of certain aromatic products.

Milk is one of our most nutritious foods and for this reason it should be produced and handled in such a way that the flavor is never damaged either by feeding of strongly flavored feed or weeds to cows or by handling it in an insanitary or faulty manner. The milk should be cooled to a low temperature as soon as it has been produced.

It is more important to have a program of producing milk of fine flavor by better production and handling practices than to emphasize a program of improvement by processing in the milk plant. This does not mean that the use of the best methods of handling the milk in the milk plant should be minimized.

The Milk Score Card
(American Dairy Science Association)

<table>
<thead>
<tr>
<th></th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavor</td>
<td>45</td>
</tr>
<tr>
<td>Sediment</td>
<td>10</td>
</tr>
<tr>
<td>Container and closure</td>
<td>5</td>
</tr>
<tr>
<td>Bacteria</td>
<td>35</td>
</tr>
<tr>
<td>Temperature</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

It will be observed that 45 points of the 100 points are allotted for flavor. If the milk scores 39.5 or below, it usually has one of the following objectionable flavors: Barny or owy, feed, malty, rancid, bitter, flat, musty, salty, cooked, foreign, cardboard-tallowy, unclean, garlic or onion, high acid, disinfectant, metallic, or weedy.
Flavor of Milk From Individual Cows

There may be a considerable variation in the flavor of milk from individual cows. In one series of tests (California Experiment Station) the flavor scores of the milk from 24 cows ranged from 15 to 24.5 (maximum score 25). Feed had been withheld from the cows five hours before milking with the view of avoiding the masking of the primary flavor of the milk by a secondary flavor as might be caused by feed. Some of the defects that were present in the milk that was scored 22 or below were: Slightly salty, bitter, strongly salty, disagreeable taste and odor, rancid.

The milk from 536 cows in 12 herds produced during winter was also examined. That from 68 cows had an abnormal flavor. Of the 68 lots of milk, 34 had a salty taste, 17 had a rancid flavor after 6 hours, and 17 had an undesirable flavor.

Flavor of Milk From Herds of Cows

Over a period of five years, 349 samples of milk entered in the California State Fair were scored when the milk was from 24 to 54 hours old. Two-thirds of the samples were raw and one-third had been pasteurized. A total of 42.3 per cent of the samples had an abnormal flavor distributed as follows:

<table>
<thead>
<tr>
<th>% of All Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed flavor</td>
</tr>
<tr>
<td>Salty taste</td>
</tr>
<tr>
<td>Rancid flavor</td>
</tr>
<tr>
<td>Oxidized flavor</td>
</tr>
<tr>
<td>Heated flavor</td>
</tr>
</tbody>
</table>

Practically all the feed, salty and rancid flavors were common in the raw milk, and the oxidized and heated flavors were common in the pasteurized milk.

Classification of Flavors

1. Flavors caused by the Feed and Weeds consumed by the cow.
   To this group belong feeds such as silage, alfalfa hay, turnips, kale, apples, potatoes, beet pulp, beet tops, rape, cabbage, and also weeds such as garlic, scaleweed, dog-fennel, tarweed, pepper-grass, wild mustard and others.
2. Flavors caused by the condition of the animal.
   To these belong:
   (a) Those due to advanced lactation
   (b) Those due to the individuality of the cow
   (c) Those due to digestive disturbance
   (d) Those due to an infected udder

3. Flavors produced after the milk is obtained from the cow.
   (a) Absorbed-cellar, musty, smoky, gasoline, barny, unclean, refrigerator, vegetable, fruity.
   (b) Due to bacteria - sour, gassy, cheesy, and others.
   (c) Due to chemical and physical changes - tallowy, oily (freezing), rancid, oily-fishy, metallic.
   (d) Due to the addition of foreign materials - soapy, alkaline, disinfectant, medicinal salves, etc.

Rancid Flavor

1. Cause.

Rancid flavor in milk is common during the fall and winter months when the cows are late in their lactation period. It appears that the feeding of dry feeds, and especially poor-quality hay, favors the development of the defect.

The milk obtained from the cows that are in an advanced stage of the lactation period may be salty. It should not be used for human consumption. The rancid-bitter flavor develops in the milk when this is stored for some time. The flavor is more pronounced in the cream. Pasteurization will not eliminate the rancid flavor but the heating process (if high enough) destroys the chemical substance involved in the production of the flavor. This chemical substance is the enzyme lipase which is present in the milk when this is obtained from the cow. It acts on the butterfat. Objectionable rancid-bitter flavored fatty acids (Butyric, caprylic, caproic acids) are produced. Storing the milk at a low temperature appears to have no retarding effect on the activity of the enzyme. Fluctuation of the temperature of the milk and shaking or agitating the milk accelerates the activity of the enzyme.

2. Control Measures.

(a) Do not use milk from cows that are late in their lactation period.
(b) Dry off cows that are late in their lactation period.
(c) Do not use milk that is salty.
(d) Obtain a sample of milk from each cow in the herd. Store this in glass bottles for 48 hours at a temperature of from 40° - 50°F.
Heat the milk to 100º F., and note the odor and flavor.

(e) Dry off cows whose milk turns rancid after storage for 48 hours.

Barny Flavor

1. Cause.

Milk from dirty cows milked in a poorly cleaned and insufficiently ventilated barn by a producer who has dirty hands and clothes will have a pronounced barny flavor. Some of the dirt will fall into the milk. In addition, there are certain bacteria, naturally found in manure, that may produce the flavor in milk if they have been introduced into the milk and allowed to multiply in it.

2. Prevention.

It is unnecessary to go into details regarding the prevention of the flavor. Briefly, it means:

(a) Clean cows
(b) Clean and well-ventilated barns
(c) Clean hands and clothes
(d) Removal of the milk from the barn as soon as it has been obtained from the cow.

Foreign Flavor

(Gasoline, Medicine, Turpentine, Disinfectant, Chemical.)

1. Cause.

If milk cans or other utensils have been used for gasoline, turpentine or kerosene, it is practically impossible to remove the odor from the cans. The milk, if placed in such cans, will invariably possess an undesirable taste from the materials. If such milk is used it may taint the balance of the milk placed in the milk plant supply tank. Medicinal flavors, suggesting iodine, iodoform, and carbolic acid, have been observed in milk. They may be caused by medicine administered to the cow. The feeding of seed grain preserved with paradichlorbenzene (Montana) was found to give an objectionable foreign, medicinal flavor to milk.

2. Prevention.

To prevent the flavor never use milk cans or pails for gasoline or kerosene or other similar products. Avoid using strong-smelling fly sprays immediately before or during milking time. Do not use
soap for washing utensils. For chemical sterilization of utensils do not use coal-tar disinfectants. Use approved chemical sterilizing compounds. Prepare the chemical solution as recommended. Do not use milk that has an objectionable foreign flavor. If ointment is used on cows' teats, be sure that none of this comes in contact with the milk.

Sour Flavor

1. Cause.

The use of improperly cleaned and sterilized pails, milking machine, strainer, cooler, and cans, and the lack of cooling the milk to a low temperature is the cause of this defect. Lactic acid bacteria in large quantity are added to the milk by unclean and unsterilized utensils. If the milk is kept at a temperature favorable for the growth of the organisms (60° to 100° F.) a portion of the milk sugar is changed to lactic acid with the production of a sour flavor. The undesirable flavor may be noticed by smell and taste when only a slight development in acidity has taken place.

The use of sour-smelling milking machines, strainers, or cans for milk results in giving the milk an undesirable flavor and odor.

2. Prevention.

Sour flavor is easily prevented by keeping dirt out of milk by using properly cleaned and sterilized utensils and by cooling the milk quickly to a low temperature (40° to 50° F.) and keeping it cold until it is shipped to the milk plant.

Unclean Flavor

1. Cause.

An unclean flavor may be characterized as a very unpleasant flavor suggestive as being caused by a combination of milking unclean cows in a dirty barn, using either dirty hands or an unclean milking machine, using poorly cleaned utensils, and straining the milk through a dirty strainer cloth.

2. Prevention.

To avoid the flavor it is necessary to use sanitary methods during the production and handling of the milk.
Salty

Milk from cows that are late in their lactation period often has a salty taste. The only remedy for this defect is to turn the cows dry.

Feed and Weed Flavor in Milk

At the Montana Experiment Station, milk was examined at intervals over a three-year period. One hundred fifty-one lots of milk were examined before and after pasteurization; feed flavor was present in 61 lots of milk and cowy or smothered flavor was present in 24 lots. The milk was examined by experienced judges after storing for 8, 32, and 56 hours' storage at 38° F. The feed flavor was generally intensified during the storage period. Pasteurization seems to remove the feed flavor but a definite oxidized flavor developed in 44 samples of pasteurized milk.

In Oregon, a state-wide market milk and cream grading was held during 1942. The flavor scores of 102 samples of pasteurized milk ranged from 30 to 41 and averaged 38 points (maximum 45 points). Common defects were feed, cooked, oxidized. A total of 41 samples (40 per cent) were criticized for feed flavor.

Influence of Season of Year on Flavor of Milk

The period of the year when certain objectionable flavors are most common in milk was determined by Trout at the Michigan Agricultural Experiment station:

<table>
<thead>
<tr>
<th>Flavors</th>
<th>Time of Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grassy</td>
<td>May, June, September, October</td>
</tr>
<tr>
<td>Rye</td>
<td>April, May</td>
</tr>
<tr>
<td>Silage</td>
<td>November, December, January, February, March, April</td>
</tr>
<tr>
<td>Alfalfa pasture</td>
<td>July, August, September</td>
</tr>
<tr>
<td>High acid, sour</td>
<td>June, July, August, September</td>
</tr>
<tr>
<td>Malty</td>
<td>October, November, December, January, February, March</td>
</tr>
<tr>
<td>Salty</td>
<td></td>
</tr>
<tr>
<td>Barny</td>
<td>November, December, January, February</td>
</tr>
<tr>
<td>Rancid</td>
<td>November, December, January, February, March</td>
</tr>
<tr>
<td>Oxidized</td>
<td>December, January, February, March, April</td>
</tr>
<tr>
<td>Foreign</td>
<td>Occasionally or spotty</td>
</tr>
</tbody>
</table>
The influence of feeding various feeds to cows at different intervals before milking on the flavor of milk has been studied by a number of investigators.

At the California Experiment Station it was found that when full rations of alfalfa hay (15 pounds), green alfalfa (34-40 pounds), clover hay or corn silage (5-12 pounds) fed 1 to 2 hours before milking produced strong undesirable feed flavors and odors. When these feeds were withheld during the 5-hour interval before milking, objectionable feed flavors were eliminated. Smaller quantities of the flavor-producing roughages — for example, 5 pounds of alfalfa hay, 10 pounds of green alfalfa, or 10 pounds of corn silage — fed 1 to 2 hours before milking, imparted to the milk a distinct and undesirable flavor, evident to one accustomed to judging milk.

When green barley, wild oats, foxtail and filaree were fed to cows as sole sources of roughage in quantities required for satisfactory nutrition, 2 hours before milking, undesirable feed flavors varying from slight to strong were imparted to the milk in every instance. Cows being grazed on these feeds should be removed from the pasture at least 5 hours before milking, if such flavors are to be avoided, it was recommended.

It was found that when tame oat hay was fed in the amount of 8 to 9 pounds to cows two hours before milking, only a slight after-flavor in the milk was produced.

Improperly cured hay having a musty odor was found to transmit a musty flavor to the milk.

The usual concentrate feeds - rolled barley, coconut meal, soybean meal, cottonseed meal, wheat bran, and dried beet pulp - when fed 1 or 2 hours before milking, in quantities used by the average commercial dairyman, did not give milk sufficient flavor to make it undesirable to the average consumer.

Rolled barley and beet pulp, however, when fed alone in 5-pound quantities or more, 1 and 2 hours before milking, gave either a detectable flavor or an after-flavor; but the judges believed that these would not be noticed in cold milk by the average consumer.

Wheat bran seemed to improve the flavor of the milk when fed in 5 1/2 to 7 pound quantities 1 hour before milking. It gave more flavor to the milk than was present in the control samples, and the flavor was reported as pleasing.

Babcock of the Bureau of Dairy Industry, United States Department of Agriculture summarized in the Journal of Milk Technology, Vol. 3, No. 1, 1940, the Bureau's extensive work in connection with the studies of the influence of feeds on the flavor of milk. He stated
that, "feed flavors are transmitted to the milk mainly through the body of the cow and as a rule, only for a few hours after the cows consume the feed. Because of this fact most highly flavored feeds can be fed immediately after milking without affecting the flavor of the milk produced at the next milking. In fact, in the case of green alfalfa, it has been shown that changing the time of feeding from one hour before milking to three hours before milking, decreased the intensity of the abnormal flavor, and feeding five hours before milking practically eliminated it. On the other hand, large quantities of feeds like cabbage and turnips even though fed immediately after milking, may at times slightly taint the flavor of the milk produced at the next milking. These taints, however, are slight and would seldom be noticed by the average consumer. Feeds that had only a slight effect when fed before milking had no detrimental effect when fed after milking.

"Feeding experiments with garlic showed more conclusively that feed flavors enter milk mainly through the body of the cow. These experiments also showed the time required for flavors to enter the milk. This work showed that garlic flavor and odor can be detected in the milk when the milk samples are taken one minute after garlic is fed. The intensity of the garlic flavor increases and at 10 minutes after feeding a high degree of intensity is reached. Garlic flavor is present to a very objectionable degree in milk from cows that have consumed one-half pound of garlic 4 hours before milking. Milk drawn 7 hours after the cows consume one-half pound of garlic is practically free from garlic flavor. Strong garlic flavor is found in milk drawn 2 minutes after the cows inhale garlic odor for ten minutes, and practically disappears in 90 minutes after such inhalation. Garlic odor is readily perceived in samples of blood drawn 30 minutes after the cows are fed 2 pounds of garlic tops, and strong garlic odor is present in the blood drawn 45 minutes after such feeding, indicating that the flavor is transmitted by the blood to the udder.

"Work with bitterweed further confirmed the fact that flavors enter milk mainly through the body of the cow. This weed is frequently found in southern pastures and although it is practically odorless, it imparts its flavor to the milk when the cows eat it. Work with this weed also showed it to be an exception to the usual rule 'That feed flavors are more pronounced in cream than in the milk from which the cream is taken,' the flavor produced by bitterweed being more pronounced in skim milk than in whole milk and much less pronounced in the cream than in the skim milk. It further showed that there also may be exceptions to the rule that 'feed flavors are not imparted to milk except for a few hours after feeding.' When cows consume 10 pounds of bitterweed, the flavor is present in the milk produced 24 hours later, but milk produced 27 hours later is practically free from a bitter flavor."
Babcock stated that abnormal flavors in milk as delivered by the producer can be prevented by adopting the following practices: "Feed all highly flavored feeds immediately after, never just before, milking. Remove cows from weed-infested pastures from 4 to 7 hours before milking."

In a discussion of the effect of feed on the flavor of milk (News from the News, Staley Mfg. Co., Vol. IV, No. 9, 1943), Espe stated: "The flavor imparted to milk by garlic is due to allyl sulphide which is split off during the process of digestion.

"Most undesirable weed flavors are due to certain volatile fatty acids and essential oils which pass through the blood into the milk. Most of the essential oils (non-lipid products consisting primarily of aromatic esters, aldehydes and ethers) are eliminated in the urine. As these undesirable products are destroyed or eliminated from the blood, their concentration in the milk also decreases due to diffusion back into the blood or through some metabolic activity.

"The off-flavor imparted by Frenchweed, is probably due to the production of excessive amounts of indole.

"Cockle burr is most serious when young; other types of weeds develop a bitterness as the stem becomes woody or as the fruit (seeds) develops."

Relation of the Color of Milk to its Flavor

Experiments to determine the relation of the color of milk to the flavor were conducted at the New Jersey Agricultural Experiment Station by Bartlett, Garrett, Reese and Hartman. They used a Lacto-photometer for measuring the color of milk.

The investigators concluded from their studies that "Milks that are higher in color than the average of the breed are most likely to have the best flavor and are least likely to develop objectionable oxidized flavors."

Cooked Flavor in Milk

Consumers of milk object to a cooked flavor in the pasteurized product. Much of the former objection to pasteurized milk can be attributed to a cooked flavor. The defect is much less common now when the pasteurization temperature of the milk and the length of the time of holding are much better controlled than formerly.

Gould and Sommer conducted research to obtain a better insight into the chemical changes that occur when milk is heat treated. Their results are tabulated below:
MILK USED

Temperature
Milk heated to, not held

<table>
<thead>
<tr>
<th>Deg.C.</th>
<th>Deg. F.</th>
<th>Holstein</th>
<th>Guernsey</th>
<th>Jersey</th>
<th>Skimmed</th>
<th>20%</th>
<th>35%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>168.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>72</td>
<td>161.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>74</td>
<td>165.2</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.8</td>
<td>1.5</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>76</td>
<td>168.8</td>
<td>1.4</td>
<td>1.4</td>
<td>1.8</td>
<td>2.3</td>
<td>1.8</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>78</td>
<td>172.4</td>
<td>3.0</td>
<td>3.6</td>
<td>3.2</td>
<td>0.2</td>
<td>3.8</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>80</td>
<td>176.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>1.6</td>
<td>3.8</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>82</td>
<td>179.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Total time to reach highest temperature 15 minutes.

<table>
<thead>
<tr>
<th>Flavor Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = No cooked flavor.</td>
</tr>
<tr>
<td>1 = Questionable cooked flavor.</td>
</tr>
<tr>
<td>2 = Faint cooked flavor.</td>
</tr>
<tr>
<td>3 = Distinct cooked flavor.</td>
</tr>
<tr>
<td>4 = Strong cooked flavor</td>
</tr>
</tbody>
</table>

These data show that heating milk momentarily to 76° to 78° C. (168.8° to 172.4° F.) caused a cooked flavor in milk. If the milk was held for 3 minutes at the various temperatures, a cooked flavor was noticeable when a temperature of 74° to 76° C. (165° to 168.8°F.) was used. When the milk was held for 30 minutes, a cooked flavor was observed in the milk heated to 70° to 72° C. (158° to 161.6° F.).

The investigators attributed the cooked flavor of milk to the formation of sulphides during heating. Although the heat labile (unstable) sulphides are contributed by milk serum, the protein material associated with the fat globules in whole milk and cream caused more intense liberation of sulphides. This material passes out into the buttermilk. The higher the fat content of the cream, the lower the temperature to cause cooked flavor intensity.

1. Causes.

(a) Too high pasteurization temperature.
(b) Too high temperature of heating medium.
(c) Too little agitation of milk during heating with vat method.
(d) Too small rate of flow of milk through short-time pasteurizer.
(e) Deposit of milkstone on heating surface.
(f) Holding milk too long at pasteurization temperature.
(g) Inaccurate thermometers.

2. Prevention.

(a) Use equipment free from milkstone.
(b) Operate the pasteurizer correctly.
(c) Maintain a proper temperature of heating medium.
(d) Use tested thermometers.
(e) With a H.T.S.T. pasteurizer, operate this to as near capacity as possible.

Rancid Flavor in Homogenized Milk

Homogenization of whole milk at a temperature from 80° to 120° F. was found by Trout to be the temperature zone that would result in a definite rancid flavor of the milk upon standing. A homogenization temperature of 20° F. below or above these temperatures also resulted in the development of rancid flavor and accompanying increase in acidity. When homogenized at temperatures from 80° to 120° F. and the milk cooled and held at below 40° F., a definite rancid flavor appeared in the milk after 2 hours. Trout found that there was no advantage so far as the flavor of the pasteurized milk was concerned in homogenizing before or after pasteurization. A temperature of 130° F. at which to homogenize before pasteurization involves less risk from rancid flavor development in the event of a delay of pasteurization, he concluded.

Homogenization prior to pasteurization is to be preferred from a sanitary point of view. Raw non-homogenized milk must never be added to homogenized milk as this will result in lipase activity and the development of rancid flavor, he warned.

Oxidized Fat-Tallowy-Cardboard Flavor

Oxidized fat-tallowy-cardboard flavor is generally recognized as being the most common objectionable flavor defect of pasteurized market milk in the United States at the present time. It may also appear in raw milk. The flavor may occur during all seasons of the year, but it is most prevalent during the fall and winter months.

By oxidation is commonly meant:
(a) To combine the product with oxygen, or the addition of more oxygen.
(b) To remove hydrogen in the substance by oxygen.

Conversely, reduction means:
(a) The removal of oxygen.
(b) The addition of hydrogen.
Causes of Oxidized Flavor in Milk

1. The feed consumed by the cow.

It has been observed that a change from a ration that consists primarily of dry feeds to a ration that contains considerable succulent feeds, such as pasture, aided in overcoming the defect when this was present in the milk. Certain feeds high in Carotene (provitamin A) content have been found to prevent the development of the oxidized flavor in some cases. The feeding of feeds high in vitamin C (ascorbic acid) content has also been demonstrated to aid in preventing the development of the defect. Simply a change of feed has been found to be beneficial in some instances.

2. The cow.

The milk from certain cows may be more susceptible to the development of oxidized flavor than that of others. It has been shown that an oxidized flavor may develop in the milk from certain individual cows when the milk has not come in contact with the metal or catalytic agent. This is known as the "spontaneous" type of oxidation. When this milk is mixed with the balance of the milk produced by the herd, an oxidized flavor may develop in the mixed milk. The breed of the cow and the age of the cow appear not to influence the occurrence of oxidized flavor.

3. The presence of oxygen in the milk.

Milk as it is obtained directly from the cow's udder contains practically no oxygen. During the production of the milk several milligrams of oxygen are added to each quart of milk, and by the time the milk reaches the milk plant it may contain approximately 8 to 10 milligrams. The presence of this oxygen, plus the oxygen added during processing and handling, favors development of oxidized flavor in the milk. Recently published findings (by Sharp, Guthrie, and Hand of New York (Cornell) Agricultural Experiment Station in Jour. Dairy Sci., Vol. XXIV, p. A253) indicate that the presence of oxygen in the milk favors the development of oxidized flavor and also favors the destruction of vitamin C. It was found that:

The oxidizing potential of milk is expressed as the oxidation-reduction potential (Eh). It is measured in volts. Fresh milk has a potential of + 0.3 volt. The positive reading is due chiefly to the presence of dissolved oxygen. If the oxygen is completely removed by deaeration (or as in low quality milk allowing the bacteria to consume it) the reading is reduced to - 0.2 volt.
Factors which reduce the Eh and the susceptibility of milk to oxidized flavor are:

(a) Oxygen removal
(b) Vitamin C addition
(c) High temperature treatment
    (Sulphydryl reducing Substance)

Factors which increase the Eh and the susceptibility of milk to oxidized flavor are:

(a) Copper
(b) Hydrogen peroxide
(c) Oxygen
(d) Oxidizing agents

The oxidation reduction potential is a measure of the intensity factor with respect to oxidation or reduction.

A strongly positive + potential indicates intense oxidizing conditions.

A strongly negative - potential indicates intense reducing conditions.

(a) The development of oxidized flavor and destruction of vitamin C in pasteurized milk may be prevented by the removal of oxygen from the milk at the time of pasteurization.

(b) Milk at the time it is produced contains an average of 22.2 milligrams of vitamin C per liter, but this is reduced to 2.0 milligrams by the time the pasteurized milk is consumed.

(c) Mixed night and morning milk as delivered to a country milk plant was found to contain 18.9 milligrams vitamin C per liter.

(d) Passage through the country milk plant did not decrease the vitamin C content much, but increased the susceptibility to oxidation due to increases in copper and air content.

(e) Tank car transportation to New York City resulted in a further 3 to 5 milligrams loss of vitamin C.

(f) At the city the cold milk was practically saturated with oxygen, the average being 10.3 milligrams per liter.

(g) During pasteurization by the holding method, 2 to 5 milligrams of vitamin C may disappear.
(h) When milk is heated over external surfaces it loses some oxygen, but it takes more on when cooled over similar surfaces.

(i) As milk is introduced into a high-vacuum chamber at from 105° to 115° F., a drop in temperature of from 7 to 15 degrees occurs and the oxygen along with 0.5 per cent water vapor from the milk passes off as the milk boils. The total cost is 3 to 4 cents per 1000 pounds milk.

(j) True vacuum bottle fillers or bottom-up type fillers will prevent re-entry of oxygen.

(k) Milk with 10.4 milligrams of vitamin C per liter when aerated raw and pasteurized at 160° F. for 15 seconds showed 19.1 milligrams ascorbic acid (vitamin C) after three days and no oxidized flavor.

Summary

De-aerated milk that had been kept for three to four weeks maintained a high flavor score and no oxidized flavor developed, whereas a pronounced oxidized flavor developed in the original milk which had not been de-aerated. The de-aeration process removed some of the flavor not desirable in milk.

It was pointed out by these investigators in another report, that if the vitamin C originally present in milk and milk products which enter human consumption were preserved it would equal approximately one-half of the vitamin C of the citrus crop in the United States.

4. Number of bacteria in the milk.

Oxidized flavor is more common in milk containing only a few bacteria than in milk that contains a large number. In low-count milk there is little utilization of oxygen by the bacteria; hence, there is a greater opportunity for oxidation of certain milk constituents.

The production of high-count milk, or the addition of bacteria, or certain anti-oxidants, are definitely not methods to use for control.

5. Metals.

Copper and iron and certain metal alloys containing copper, such as nickel, silver, bronze, nonel metal, etc., when in contact with
milk, may react with the milk to form metallic salts. These salts act as catalysts; that is, they effect a change in some of the milk constituents. They are responsible for oxidation of some of the constituents of the milk and giving rise to an oxidized-tallowy-cardboard flavor. Copper is the most active of the metals. The exposure of the milk to a small copper alloy surface, as for instance to a short length of pipe, a copper thermometer bulb, or to a coil that shows exposed copper, is sufficient to cause oxidation.

Stainless steel, tin, and aluminum nonreactive with milk and cream.

6. Pasteurization.

Milk may develop an oxidized flavor even where pasteurized in glass or other non-metal containers. Such development is referred to as being "spontaneous." There is no known prevention except to change the feed of the cows. An oxidized flavor will usually develop within a short time in milk that is normally not of the "spontaneous" type, but "susceptible," when it is handled in contact with copper or iron or alloys of copper. Only a minute amount of copper - less than one part per million - in the milk may cause the oxidized flavor.

7. Test for copper.

A test for copper may be used to determine the presence of copper in milk (Ritter's method):

(1) Add 10 ml. milk to a test tube.
(2) Heat milk to 194° F. by placing the tube in boiling water for 3 minutes.
(3) Cool to 70° F.
(4) Add one drop of each reagent (see below) and mix well.
(5) Let stand at 70° F.
(6) Observe the development of a blue color. If considerable copper is present in the milk the blue color will develop quickly. With a small amount of copper the blue color may not appear for 1 or 2 hours or longer.

Samples obtained from different places during the processing and handling of the milk should be tested. A copper-free sample should be used as a check.

Reagent A -- Dissolve 100 milligrams para-amino-dimethylanilin-sulphate in 10 ml. distilled water. Boil in the presence of bone black. This removes certain colored oxidation compound. Filter through filter paper. Prepare fresh solution as used.

Reagent B -- One per cent alpha-naphthol in ethyl alcohol.

Reagent C -- One per cent hydrogen peroxide.
8. Exposure to light.

The exposure of milk for only a short time, such as 15 minutes, to sunlight favors the development of a tallowy-oxidized flavor. The exclusion of wave lengths below 740 mu will protect the milk (Ohio).

Milk Constituents Involved When Oxidized Flavor Develops.

When the oxidized flavor is caused by copper or certain other metals it appears that the fatty compounds known as phospholipids are oxidized and the resulting products are responsible for the undesirable flavor. Average milk contains 0.075 per cent of the phospholipids known as lecithin and cephalin. Lecithin contains the fatty acids, stearic acid and oleic acid. The oleic acid is unsaturated and chemically active.

When milk is exposed to light the oxidized flavor appears to be the result of the oxidation of some of the milk fat. Perhaps some of the less known unsaturated fatty acids of milk fat are involved.

Determining the Susceptibility of Milk to The Development of Oxidized Flavor

A simple test for determining the susceptibility of milk to the development of oxidized flavor is as follows: (Based on method developed by G.M. Trout).

1. Divide one quart raw milk equally between 3 one-pint milk bottles.
2. Keep one bottle as a control. Pasteurize the two others in a water bath at 143° F. for 30 minutes and cool to 40° F. To one bottle of pasteurized milk add 3 ml. of copper sulphate solution prepared by adding 100 milligrams copper sulphate (CuSO₄ • 5H₂O) to one liter distilled water. Approximately 0.25 parts per million of copper is added to the milk.
3. Store the three samples for 3 or 4 days at 40° F.
4. Examine each sample for flavor.
5. If no oxidized-tallowy flavor develops in the milk containing no added copper but develops in the milk which contains copper, the milk is susceptible to the development of the defect when copper-exposed equipment for milk processing is used.
6. Instead of adding 3 ml. of copper solution 6 ml. may be added, if no oxidized-tallowy flavor develops during storage the milk is little susceptible to the development of the defect. Another method is to use different lengths of bright copper wire in test tubes containing milk during laboratory pasteurization of these.
Summary

To prevent oxidized-tallowy-cardboard flavor in market milk, observe the following:

1. Determine the susceptibility of the milk in each vat of milk pasteurized in the milk plant to the development of the oxidized defect.
2. If necessary, test also for susceptibility of the milk furnished by each producer. Eliminate the milk from cows whose milk quickly oxidizes.
3. If possible add more succulent feed to the cows' ration. Simply a change in the feed may also be helpful.
4. On the farms use utensils that are free from exposed copper or iron, or copper-bearing alloys.
5. Recondition utensils that show rust spots.
6. Do not expose milk to sunlight or strong light.
7. In milk plants be sure all copper and iron surfaces are covered with a good coating of tin. This includes pumps, bearings, pipes, pipe fittings, thermometer bulbs.
8. Do not expose milk to copper-bearing alloys. Use stainless steel or aluminum for dairy equipment, or if copper is used be sure that all parts are covered with a heavy coating of tin.
9. Do not expose the bottled milk to sunlight or strong light.
10. Avoid incorporation of air with milk.

Old Flavor

A study to determine the length of time pasteurized milk could be held at different temperatures was recently made at the Cornell University Agricultural Experiment Station by Dahlberg. The following are excerpts from his conclusions based on the data obtained.

"Modern Electric household refrigerators maintain temperatures well under 50°F. At such temperatures pasteurized milk was found to keep well for 3 or 4 days or even longer in the summer months, as judged by bacterial content and flavor scores. The keeping quality of the pasteurized milk was good enough to permit every-other-day delivery of milk without any impairment in wholesomeness. It should be emphasized, however, that milk does not improve with age. Milk delivered every other day is freshly pasteurized before delivery and is not a day old. The storage problem applies only to the home refrigerator which must have capacity for a two-days' supply of milk.

"Pasteurized milk should not be stored above 50°F. in the home refrigerator.

"When August or October milk was stored at 35 to 40°F., the flavor was good for seven days at which time the samples were discarded."
"When milk was held at 45 to 50° F., the flavor was good for four days in August and for seven days in October and February.

"When milk was stored at 55 to 60° F., the flavor of the August milk was good with certainty for two days as compared with three days in October and February."

-- o o o --

"We had just moved into a new apartment and were besieged by salesmen for everything from laundry service to life insurance. One busy day a dairyman came to the door. "No," I said firmly, "my husband and I don't drink milk."

"Be glad to deliver a quart every morning for cooking."

"That's more than I need," I replied, starting to close the door.

"Well, ma'am, how about some cream? Berries comin' in now, and . . . ."

"No," I said shortly, "we never use cream."

The little man retired slowly, and I congratulated myself on my sales resistance. The truth was that I had already ordered from another dairy and this seemed the easiest way out.

The following morning, however, the same dairyman appeared at the door, a bowl of dewy strawberries held carefully in one hand and a half-pint bottle of cream in the other.

"Lady," he announced, as he poured the cream over the berries and handed them to me, "I got to thinkin' -- you sure have missed a lot!"

"Readers' Digest"

We changed dairies.
RENNET AND ITS IMPORTANCE IN CHEESE MAKING

Rennet extract contains an enzyme which is obtained from the fourth stomach of a young calf which had been milk-fed. The enzyme (or enzymes) is extracted from the dry, salted "rennets" by brine. The extract is generally adjusted with salt so that it has a Baume reading of 18 degrees. The extract is clarified and stored in large vats in a cool room for several months and is then filtered before it is shipped to the trade. The extract is accurately standardized so that it will have standard curdling power.

In a warm room a good commercial extract in a closed vessel will lose about 3 per cent of its strength a month. In a cool cellar it will lose 1 per cent or less a month, and in cold storage, above the freezing point, the loss in strength is still smaller.

It is not advisable to compare a sample of rennet just received from the manufacturer with rennet which has been held in storage a long time, especially in a warm room, and it is inadvisable to judge the relative strength of rennet extract by changing brands from one day to another in different vats of milk as these may vary greatly in action with the same rennet.

One rennet manufacturer points out that when a rennet extract is made to a standard curdling power at shipping time, there are two factors that should be considered by the cheese maker when judging the effectiveness of different rennet extracts in curdling milk. They are:

1. The variation in the curdling time of the milk with the same extract.
2. The length of time and manner of storing the extract.

Hales has commented as follows with reference to testing the coagulating power of rennet:

"In view of the changing character of milk from one season of the year to another, definite rules cannot be followed in cheesemaking. Because of the many conditions that affect the coagulation of milk by rennet, a practical test, which indicates the changing properties of milk from day to day, has been devised. This is known as the rennet test. This test not only changes with an increase in acidity, but is also affected by the changes in the composition of milk and its curdling properties. In making the rennet test, cheesemakers are, therefore, really measuring in a practical way many properties of milk other than its ripeness which is often thought to be the thing that determines the complete results of this test."

"To be most valuable in daily cheesemaking operations, the rennet test should be made with rennet extract of the same curdling power and with milk at the same temperature. When cheesemakers wish to test the comparative strength of two different lots of rennet, it is
essential that both samples be tested in the same milk and the best comparison can be made in sweet milk which is not changing rapidly in acidity. The results should be checked by making rennet tests in the following order: 1. Sample A; 2. Sample B; 3. Sample B; 4. Sample A.

"After the tests have been made in this manner, the average of the two results of each sample should be calculated. This procedure will compensate for changes in acidity of milk between tests, providing that they are made in consecutive order without any more time elapsing than is necessary to clean out the rennet test cup and prepare for the next test. Hence, the average of the tests will give a true comparison of the strength of the two samples.

"To further illustrate the method of figuring the comparative strength of the two samples, we will assume that the rennet tests were as follows:

1. Sample A - 3.0 divisions on the Rennet Test Cup.
2. Sample B - 3.5 divisions on the Rennet Test Cup.
3. Sample B - 3.25 divisions on the Rennet Test Cup.
4. Sample A - 2.75 divisions on the Rennet Test Cup.

The average of the two tests for Sample A would be:

\[
\frac{3.0 + 2.75}{2} = 2.875
\]

The average of the two tests for Sample B would be:

\[
\frac{3.5 + 3.25}{2} = 3.375
\]

Sample A obviously is the stronger, for it curdled the milk quicker. Expressing the per cent of strength in terms of A, the calculation would be made as follows:

\[
\text{Average test of sample A} = 2.875 \\
\text{Average test of sample B} = 3.375 \\
x 100 = 85 \text{ per cent}
\]

In other words, sample B is 85 per cent the strength of sample A.

What is Meant by the Word Enzyme

An enzyme is defined as an organic catalyst which is produced by a vegetable or an animal cell and the activity of which is entirely independent of the life processes of such cell.

Organic = pertaining to, or obtained from living matter or organisms.

Catalyst = a substance which alters the velocity of the chemical reaction without undergoing any apparent chemical or physical change itself and which does not become a part of the product formed.
The enzyme rennin or chymase in rennet extract is protein coagulating. Other enzymes not present in rennet extract may act on fats, carbohydrates and other compounds. The rennet enzyme coagulates the milk casein but does not coagulate milk albumin.

One part of rennin is sufficient to coagulate 3 million parts of milk. The rennin enzyme itself is thought to be a protein, similar to albumin. It is possible that the optimum temperature is near the body temperature. (Optimum = best for action). The enzyme is destroyed when exposed for a few minutes at a temperature of $140^\circ$ to $149^\circ$ F.

**Nature of Coagulation of Casein by Rennin**

The casein in milk exists as colloidal calcium caseinate. The rennin action is dependent on the presence of a soluble calcium salt. Coagulation of casein with rennin is best at approximately $6.0$ to $6.4$ pH and at a temperature of $104^\circ$ to $107^\circ$ F. It is slower at a lower acidity (higher pH). No coagulation takes place when the temperature falls below $55^\circ$ F or above $140^\circ$ F. The coagulated casein is known as calcium paracaseinate.

The exact chemical reaction and physical change that takes place during coagulation of casein with rennin has not been fully determined.

(Colloid = a substance of gelatinous nature, diffusing very slowly or not at all through animal or vegetable membranes (parchment). Examples are milk and egg albumin, milk casein, starch. The colloidal casein can be obtained from milk by centrifugation.)

There must be a proper relation of the calcium, potassium and sodium salts in the milk for proper rennin action. Too high a content of calcium salt results in a firm coagulum and too low a calcium content results in a soft coagulum. If the coagulum is too firm a small amount of water (3 to 5 per cent) may be added to the milk before the rennin is added. Pasteurization at too high a temperature, causes a softer coagulum on account of a change in the soluble calcium salt present. A softer coagulum results if the cream from the milk is homogenized, then added. The cream should not test over 20 per cent. When this cream is added to the milk, the adsorption of the casein on the larger fat surface increases the water-holding capacity of the casein.

If the milk has been over pasteurized or if it is low in calcium salt, a firm coagulum can be obtained by the addition of a small amount of calcium chloride.

Swedish experiments have shown that the addition of 9 grams of
calcium chloride to 100 pounds milk (0.02 per cent) and using less than the normal amount of rennet gave a good flavor, body and texture, a 3 per cent greater yield and faster ripening than when the normal amount of rennet and no calcium chloride were used. Too much calcium chloride, however, results in a corky body and an open texture.

The Influence of Rennin Enzyme on the Ripening of Cheese

Experiments were conducted at Massey Agricultural College in New Zealand to determine the influence of different amounts of rennet extract on the speed of ripening of cheddar cheese. (N.Z. Dairyman, January 19, 1935, and Bul. 38, N.Z. Dept. of Scientific and Industrial Research, 1933.)

The control cheese was made from milk with which 3 ounces rennet per 1000 pounds was used and the experimental cheese was made with the addition of 5 ounces of rennet per 1000 pounds milk.

Cheese of different moisture contents and firmness was made. The cheese ripened at different temperatures. Split batches of cheese were made. The milk was flash heated at 150°F. then cooled to 85°F. before used in manufacturing.

The following observations were made during the manufacture of the cheese:

1. The use of the larger amount of rennet shortened the time from setting to cutting, 5 to 10 minutes.

2. To prevent too rapid expulsion of whey from the curd particles, the increase in the temperature during cooking was slower at first with the experimental cheese with the view of facilitating the development of acid at the same rate as in the control vat.

3. The cooking time was the same for both lots.

4. The increased amount of rennet used did not change the loss of fat in the whey.

On the basis of the examination of the finished cheese, the following conclusions were made:

1. The use of a higher percentage of rennet caused a more rapid ripening. Even after 14 days of curing the cheese made with larger amount of rennet showed a softer body. Later during the ripening period, after the first 14 weeks, a pasty, sticky condition developed in the experimental cheese made with the larger amount of rennet.
2. A more pronounced cheese flavor developed during the first 14 weeks in the cheese made with a greater amount of rennet. However, the cheese lacked real Cheddar flavor or "bouquet." The normal rennet cheese had an insipid flavor.

3. The quality of the cheese made with more rennet was not as good as that of the control cheese as the ripening period progressed. A definite undesirable flavor developed in the cheese that contained a high moisture content. Bitter flavor was common. When ripened at a high temperature (60°F) the experimental cheese was inferior to that of the control cheese. Closeness of the cheese was not affected by the use of more rennet.

The heating of the curing room to maintain cheese at 60°F in cold weather had a less pronounced effect on the rate of development of ripeness in cheese than had the use of additional rennet in the manufacturing process, if the cheese were to be sold at the age of 14 to 16 weeks. The cheese was first held on the factory shelves for periods up to one month, after which it was held in grading warehouses, and on board ship from New Zealand to England at a temperature of 50°F.

All of the cheese held in factory curing rooms at 45°F to 50°F and examined at 9 weeks of age had a better flavor score than cheese held at 60°F for the first fourteen days.

Most of the cheese held at the lower temperature on the factory shelves for the first one-month also graded better than those held at 60°F for the same length of time and examined at the age of 13 or 14 weeks.

None of these groups of cheese developed typical Cheddar flavor. The cheese that was cured at a low temperature retained a clean flavor while those cured at a high temperature had an unclean flavor which often was described as metallic and which was recognized as a transitional stage in the ripening of pasteurized milk cheese held at 50°F.

The effect of increased curing room temperature (60°F) on the soft bodied cheese, was particularly apparent, as a distinctive accentuation of bad flavors. Additional rennet, further accentuated the bad flavor. The higher temperature of curing also made cheese examined at 9 weeks of age more open in texture.

If spring made cheese were to be sold at the age of 9 weeks, the heating of curing rooms alone as a means of speeding up the ripening process would likely give disappointing results.

The conclusion from the experiment was that the use of a larger percentage of rennet extract was an advantage only when the cheese was to be sold before it was fully ripened. No undesirable
flavor developed when well made cheese was cured at 45° to 50° F.

It was apparent from the results that the use of 4 ounces of rennet extract in 1000 pounds of milk could be used to accelerate the ripening of New Zealand Cheddar cheese made from August to October. From then on 3 ounces would be sufficient.

Clean good quality milk must be used, the curd must be properly cooked and salted if a poor flavor is to be avoided.

When additional rennet is used, it is desirable to reduce the temperature of setting 1 to 2 degrees F. in order to avoid too rapid coagulation. The heating of the curd during cooking should be done more slowly during the first 15 minutes to prevent a film from forming on the curd particles too quickly.

"50-45-40" METHOD OF BUTTER MANUFACTURE

For a number of years buyers and distributors of butter on Pacific Coast markets have complained that the butter made in the irrigated sections of Oregon during the fall and winter months was hard and either crumbly or sticky. Complaints of excessive brine leakage during printing and subsequent to printing were also made. The butter on printing cut badly and was difficult to handle. Because of its hard and crumbly condition and poor spreading property, it did not enjoy favorable acceptance by butter buyers. As this butter was marketed in competition with butter made in sections where less dry feeds were fed to the cows, the Oregon Agricultural Experiment Station was requested by the industry to study the problem with a view of finding a possible solution. Funds for the research were provided by the state legislature.

Consumers desire butter that has a medium soft, waxy body. The physical make-up must be such that when the butter is cut with a knife, spread on bread or toast at the usual temperatures, it does not crumble or stick to the blade. Undesirable qualities of body and texture of butter are: weak, greasy, leaky, hard, crumbly, sticky, and salvy. To please the consumers, the butter must have an attractive appearance and must be of such a consistency that it can be readily handled in kitchens and at the table.

In a private communication Dr. O. F. Hunziker stated that the problem of overcoming the defects crumbliness, stickiness, and excessive hardness of butter was by far the most stubborn of all butter problems. With reference to the facts and theories that have been advanced relative to the probable causes of poor spreadability of butter, he stated, "The factors and combinations of factors that determine or influence the body and texture of butter are numerous.
On the basis of our present knowledge they have to do with the composition of the butterfat, structure of liquid fat and size of fat crystals in the butter. Some of these factors are in turn related to certain phases in the process of manufacture, such as intensity of cream cooling, temperature of butter, wash water, manner and intensity of working, and temperature at which the butter is held immediately after manufacture.

"The science of the relationship between some of these factors and their effect on body and texture is generally understood, while that of other factors is as yet largely undetermined. The proper adjustment of the multitude of factors that influence the body and texture of butter to the fluctuating character of the raw material is further complicated by the usual endeavor dictated by competitive expediency of incorporating in butter the maximum percentage of moisture permitted by law."

The research worker King, of Estonia, concluded "That the fat in butter exists in two forms; namely, in the form of globules and as a dispersion agent for the globules and water droplets." He pointed out that the so-called unprotected part of the fat must be the fat that as a continuous phase fills up the space between the fat globules and water droplets. This is the liquid fat fraction that in his opinion acts as the real dispersion agent for the water droplets, which for the greater part are between the fat globules. He referred to the work of Boysen, which showed that the number of water droplets in 1 gram of butter normally ranges from 6 to 16 billion and that the fat globules range from 9 to 25 billion.

The liquid fat phase is important from the point of view of the spreadability of butter. With respect to this Mulder of Holland stated that, "The spreadability of butter is apparently due to the sliding over each other of the fat globules and water droplets; this is favored by the liquid fat present."

Before research involving the actual experimentation to develop a satisfactory method of butter manufacture during fall and winter was begun, the Oregon Agricultural Experiment Station made a detailed study of the chemical and physical properties of the butterfat produced in the alfalfa-producing sections in Oregon. It was found that the fat of the butter during the period, October to March-April, had a relatively high melting point and a low content of unsaturated and of volatile fatty acids. These fatty acids have low melting points and if present in the fat in relatively small amounts hard butter is obtained. Crumbliness and stickiness and lack of spreadability were common in butter when the unsaturated and volatile fatty acid content of the fat was low. It was found that the feeding of grain supplements with an alfalfa hay ration did not materially change the physical and chemical properties of the milk fat. It was evident, therefore, that the immediate and practical solution of the problem of crumbliness, stickiness and excessive
hardness involved a modification of the butter making methods.

Research begun in 1937.

The research on the problem to solve the problem of crumbliness, stickiness and excessive hardness of butter was in progress from November, 1937, to January, 1942. Cooperating with the author was R. W. Stein and R. E. Stout, graduate students. The research involved:

1. Experimentation to determine the influence of different manufacturing methods on the body, texture, and spreadability of butter made from cream produced during the fall and winter months in the alfalfa-producing sections.

2. Manufacture of butter under commercial conditions in creameries by the methods that experimentation had shown were the best.

3. Examination by competent butter graders of the butter made in final tests.

4. Determination of "printability" and "spreadability" of the butter made in final tests.

5. Determination of moisture losses during and subsequent to printing of the butter made in final tests.

6. Submission to consumers of representative samples of butter made in final tests for their decision as to the butter they prefer.

Preliminary Experiments.

For preliminary churning experiments during the fall, and winter months, 1937-38 and 1938-39, was obtained cream from eight creameries located in sections where the dairy cows received a ration restricted chiefly to alfalfa hay. A total of 70 experimental churnings was made during the two seasons. The results from the preliminary work were as follows:

1. There was no detectable difference in the body and texture of the butter whether the cream was pasteurized by the flash (190° F.) or the vat (150° F. for 30 min.) method, when all other processes of the churning procedure were the same.

2. The butter made from cream cooled by means of a surface cooler was firmer and was more often crumbly than was the butter made from the cream that was cooled in a coil vat.
3. Cream cooled to a temperature of 50°F or slightly above after pasteurization and held at this temperature until the time of churning resulted in butter that was less crumbly than was butter from cream cooled to a lower temperature.

4. Cream that was churned within two hours after it had been pasteurized and cooled usually resulted in butter that was free from stickiness, but it was brittle, crumbly and short-grained. Cream that was cooled to temperatures below 48°F following pasteurization, and held from 12 to 20 hours at this temperature and then churned, resulted in butter that showed both stickiness and crumbliness. When the pasteurized and cooled cream was held overnight; in the morning heated to 120°F and held at this temperature for 15 minutes, then cooled rapidly in the vat to a suitable churning temperature and churned immediately, the butter obtained had similar body and texture characteristics to that churned soon after pasteurization and cooling.

5. Butter that had been treated by the cold wash-water method (38°F to 44°F water) was harder in the churn than butter washed with water at a higher temperature. After storage, however, the butter made by the cold wash-water method possessed a definitely softer body than did the butter made by the orthodox method.

6. The method of slow working of the butter at one-half normal speed required a longer time for complete working of the butter and the texture of the butter treated by this method was not uniformly better than that worked at normal speed.

Commercial-size Churnings Made.

During the two fall-winter seasons, 1939-1940 and 1940-1941, a total of 130 commercial-size churnings was made in the dairy products laboratory at the experiment station and in the creameries which cooperated in the study. The cream used was typical fall and winter cream produced in sections of the state where the cows were fed a ration that consisted principally of alfalfa hay.

All samples were examined when at a temperature from 48°F to 55°F. The triers, when not in use, were kept in cold running tap water at a temperature of approximately 50°F.
It was concluded from the results obtained that:

1. Churning cream immediately after vat pasteurization and cooling; or holding the pasteurized, cooled cream overnight, then reheating to 110°F., cooling quickly to a suitable churning temperature and churning at once, reduced the sticky condition, but emphasized the crumbly, hard condition.

2. Holding the vat-pasteurized, cooled cream at a temperature of from 50°F. to 60°F. overnight before churning largely overcame the hard, crumbly condition, but stickiness was quite common.

3. When low-temperature wash water was used for washing the butter granules with the hold-over, not-preheat method the sticky condition was not quite overcome, but the butter when examined was considerably softer and possessed a good spreading property.

4. Cooling the pasteurized cream to a low temperature either in a vat or on a surface cooler and holding the cream at a low temperature overnight appeared detrimental to the body and texture of the butter.

5. The addition of hot water to the cream in the churn at the time of "breaking" had no merit.

6. Extending the working time proved of no benefit under the conditions employed.

Final Study Made.

An opportunity to make a final study of the problem presented itself during December, 1941, and January, 1942, when "a colder than usual" winter was experienced. There was an absence of green feed of any kind in the fields and the cows' ration consisted of dry feeds, principally alfalfa hay and limited grain.

A total of six creameries cooperated in this particular study. Observations were made on a large number of commercial-size churnings representing somewhat more than one-quarter million pounds butter. By special arrangement with Dr. D. R. Theophilus, Head, Department of Dairy Husbandry, University of Idaho, Moscow, Idaho, and with the managers of two Idaho creameries, some of the experiments were made in two Idaho creameries, some of the experiments were made in two creameries located in southwestern Idaho. These creameries obtain milk and cream from certain eastern Oregon irrigated districts as well as from the irrigated districts in the Idaho territory. Samples of the butter made in the six creameries were examined separately, by Dr. Theophilus at Moscow, by the Federal
Butter Grader at Portland, and by the author of this report at Corvallis.

The study involved visits to the creameries and making full-sized churnings by the following three methods:

**Method A.** Churn cream immediately after pasteurization and cooling.
1. Use cold wash water (40° to 45° F.)
2. Use wash water of slightly lower temperature than butter-milk.

**Method B.** Cool cream after pasteurization to about 50° F. Hold overnight. Next morning heat the cream to about 110° F. and hold for 15 minutes, or to 130° F. without holding. Cool to a satisfactory temperature for churning.
1. Use cold wash water (40° to 45° F.)
2. Use wash water of slightly lower temperature than butter-milk.

**Method C.** Cool cream after pasteurization to about 50° F. Hold overnight. Churn next morning without preheating.
1. Use cold wash water (40° to 45° F.)
2. Use wash water of slightly lower temperature than butter-milk.

The temperature of the butter when examined in laboratories at Corvallis and Moscow was regulated to 40° to 45° F. The trier was cooled and then wiped with a paper napkin before the plug of butter was obtained. When determining the spreadability of the butter a portion of the plug of butter was spread on cold, hard-toasted bread by means of a sharp, thin-bladed, stainless steel knife. It is acknowledged that the butter would show a much better spreading property at a temperature of from 50° to 60° F. It was desired, however, to make the test when the butter was of as near household refrigerator temperature as possible. Differences in spreadability were more easily determined at the lower temperature.

From the results obtained in this particular series of experiments, it was concluded that:

1. Churning the cream immediately after pasteurization, then cooling to about 44° F. and churning at once, or holding
the pasteurized cream cold overnight; next morning pre-
heating and cooling it quickly to about 44° F. and churn-
ing at once, resulted in butter that was comparatively
hard and showed definite crumbliness but only slight
stickiness. The spreadability was generally poor. The
use of cold wash water was of no particular benefit; in
fact, it had the disadvantage in that it caused lumpiness
and a mottled color of the butter.

2. When the cream was cooled after pasteurization to a tem-
perature of 50° F., or slightly below and held overnight
at from 50° to 55° F. for churning the following morning
without further treatment, it generally resulted in butter
that was free from crumbliness, but the butter showed some
degree of stickiness. The body was quite soft and the
spreading property, considering of course that the butter
was made during the winter and contained high melting
point fat, was good. The use of this method, churning to
granules the size of small peas, then chilling and wash-
ing the granules with a large batch of cold water at a
temperature of from 40° to 45° F., followed by a thorough
working, unmistakably resulted in butter that had the
best body and texture characteristics in the series.
Stickiness could be practically eliminated by expert
workmanship. The spreading property was excellent. It
should be emphasized, however, that careful attention to
temperatures and the exercise of expert workmanship on
the part of the buttermaker are necessary if butter with
a desirable spreading property is to be obtained.

Effect of Storage Temperature on Butter Firmness.

The effect of the storage temperature on the firmness of butter
was also studied. Butter made during the fall, winter and early
spring seasons in the irrigated sections, when held at a household
or restaurant-refrigerator temperature of about 40° to 45° F., may be
somewhat firm for satisfactory cutting and spreading because of the
physical and chemical properties of the fat. Any modification
of the method of manufacture and subsequent storage of the butter that
will result in a softer, waxier, and more spreadable body would be
desirable.

Some butter distributors have advised creameries to store the
fall and winter made butter after manufacture at a somewhat higher
temperature than is common during the summer months. This is, ap-
parently, poor advice. Our research showed that when duplicate or
triplicate small samples, or 68-pound cubes of butter, were taken
directly from the churns in each creamery and placed at different
temperatures for periods of 24 hours and sometimes for several weeks,
and then kept at a temperature of about 45° F., until the temperature
of the samples became uniform, it was definitely shown that the butter
stored at the lower temperature always had the softest consistency.

Butter placed at a temperature of 0°C and then tempered, after the tempering period was always softer than butter that had initially been stored at churn-room temperature of 60° to 65°F.

When 68-pound cubes or small samples of butter made by the three methods were placed directly in a refrigerator maintained at a temperature of from 35° to 40°F, it was observed that the butter made by Method C (cream held over and not preheated, cold wash water used) was always softer than the butter made by the other two methods. It was easy to pick out from the mixed lots of butter made by the three methods the butter made by Method C. It was reported from one of the markets that butter made by Method C when cold wash water was used was too soft to print with a power printer when printed at the same temperature as butter made by the other two methods. Distributors prefer all the butter handled to be made by similar methods in order that print-room methods may be standardized.

Controlling Brine Loss

A study was also made of the loss of brine during and subsequent to printing of fall- and winter-made butter. A high percentage of the butter handled by the butter distributors in the Pacific Coast markets is printed by means of power machines. Butter is received by the distributors from widely separated sections. It is of importance that the butter from the irrigated sections of Oregon during the period October to March-April be manufactured to possess as good printability as that from other sections. The butter should have a waxy body. It should not be too hard. It should possess a well-knit texture. Considerable attention should be given to the proper incorporation of the brine with the butter. If the butter is soft and greasy, the incorporation of the brine in the form of minute droplets is impossible unless the butter is worked to such an extent that it becomes pronouncedly sticky or salvy. If too firm when being worked, the butter will not "take up" the moisture.

Expert buttermakers follow the system of regulating the moisture content of the butter so that when the butter is almost worked to completion and the first moisture test is made the moisture content will fall between 15 and 16 per cent. Trying to obtain the exact amount of moisture (usually 16.5 per cent), without having to adjust the percentage by adding water, often results in a higher moisture content than desired. Attempts to remove the surplus moisture often cause damage to the texture of the butter.

Leakiness is a Serious Butter Defect.

There are several reasons why butter should be made in such a way that it does not show leakiness either before, during, or
subsequent to printing. They are:

1. If brine leaks from a cube of butter, there is an economic loss either to the creamery or to the buyer on account of short weight.

2. If brine leaks during printing, an economic loss is sustained by the distributor.

3. If leaky butter is printed, or if the type of butter that usually leaks after printing is printed, it is necessary to compensate for the subsequent loss in weight of the printed butter while it is kept in the refrigerator or by printing overweight units.

4. When dry wraps are used, as is common with many automatic power printers, leaky butter causes an unsightly wrinkled appearance of the parchment.

5. Leakiness favors the growth of mold and bacteria.

6. Restaurant operators and housewives object to leaky butter because they think the butter contains an excessive amount of moisture.

7. When leaky butter is exposed to the air, evaporation of moisture takes place, leaving white salt crystals. These are objected to by customers.

8. Leaky butter has a briny, harsh taste.

9. When leaky butter is spread on bread or toast, brine may spurt out to the surprise and irritation of the customer.

Comments by Buyers of Butter and Others.

It was the chief purpose of the experiments to develop a method of manufacture of butter that would result in a product that would find favorable market and consumer acceptance. Therefore, it was decided to obtain the opinions of butter dealers, butter print room operators, restaurant operators, and consumers on typical examples of the butter made by several methods.

A butter dealer in Seattle stated, "We find that the consumer prefers butter that is spreadable, and does not show leakiness. Also from the distributors' point of view they are now preferring a type-bodied butter that is waxy and does not have free moisture. The reason for this is the fact that many distributors have power cutters and if the body is leaky, the loss in brine while cutting will be tremendous."
"From our point of view as marketing agents, we would much prefer the above-mentioned type as it will work in Simpson cutters or power cutters as well."

Print room operators in the creameries remarked that the butter made by the two methods "pre-heat" or "churned at once" after pasteurization and cooling was too hard and crumbly. It cut badly by means of a wire butter cutter they reported. The butter would "roll-up" or crumble on the surface when the 96-pound block of butter was cut. The wires broke frequently. Difficulty with wrapping by means of an automatic wrapping machine was also experienced. A print room operator reported that when butter that had been churned immediately after pasteurization and cooling was printed, it was crumbly and hard and would not stick together.

When butter that was made by the "pre-heat" or "churned at once" method was sold to restaurants in several of the towns visited complaints on account of the butter being hard and crumbly were made by the restaurant owners. They demanded butter with better handling and spreading properties.

When butter made in accordance with the "50-45-40" method which had proved most satisfactory, was sold to restaurant operators they reported that they were well satisfied with the cutting and spreading properties of the butter. Uniform patties could easily be cut from the pound prints. One restaurant operator demonstrated this by displaying a neat stack of patties that he had cut prior to the visit. The butter had been made in accordance with the "50-45-40" method. This man was emphatic in stating that he did not want hard, crumbly butter.

A number of Oregon State College faculty members, state officials and legislators also expressed their preference for the butter made in accordance with the method that had been found most satisfactory.

RECOMMENDED METHOD OF BUTTER MANUFACTURE DURING FALL AND WINTER

"50-45-40" Method

1. Cool the cream after pasteurization to 50°F, and maintain a temperature of the cream from 50°F to 55°F overnight. Do not cool below 50°F.

2. Inasmuch as the churning temperature varies with the amount, test, acidity of the cream, the size and type of churn, and other factors, it is important that the churning temperature be adjusted so that granules the size of small peas are formed in from 40 to 50 minutes of churning. Cream testing from 32 to 38 per cent fat is satisfactory. If the churn is filled to 40 per cent of the total capacity, a temperature of the cream from
55° to 60° F. is usually satisfactory. Do not overchurn. Large granules cannot be thoroughly washed or chilled. Do not overload the churn. Slightly underloading is preferable.

3. Spray the granules with a small amount of chilled water and allow the rinsings to drain from the churn. Do not add the rinse water from the regular supply line; place it in a tank or in a clean cream vat and correctly adjust the temperature.

4. For washing and chilling, with a normal-sized churning, add enough filtered water at a temperature of not more than 45°F so that the water and granules occupy two-thirds of the space of the churn, or add at least as much water as there was cream. Do not allow the temperature of the wash water to exceed that recommended. It may be less than 45°F, but not above this temperature.

5. Revolve the churn in high gear 12 to 15 revolutions. Then, if a roll churn, revolve in low gear, with worker connected, 10 to 15 revolutions. With a roll-less churn revolve in high gear a little longer. As the granules will be firm they will break up to a uniform size resulting in a uniform chilling of the butter during washing.

6. Drain the wash water.

7. With the churn door ajar work the granules until they have formed into a mass. Considerable water will escape.

8. Drain the water from the churn. Then add the salt. The temperature of the salt should be adjusted to 45° to 50° F. Add some chilled water in order that the moisture content of the butter at the time of making the first moisture test is 15.6 to 16.0 per cent. The amount of water to add will depend on the churning conditions as they may prevail in the different creameries. This water should be poured over the salt to aid in its solution.

9. Work the butter until it is fairly dry. Avoid overworking at this point. Then test for moisture. Working low-moisture butter almost dry, then adding necessary water to increase the moisture to the amount desired, and again working the butter until it is dry causes an increase in the working time resulting in stickiness, and as the added water may not be finely divided in the butter, leakiness generally results.

10. Add the required amount of water in order to increase the moisture to that desired. The temperature of the water should be the same as the temperature of the butter. Be sure to correctly calculate and weigh this water. Complete the working of the butter. Work the butter thoroughly. There should be
no free moisture visible. Because the butter will be firm, the working time will be longer than under summer conditions, and also when wash water warmer than recommended is used under winter conditions.

11. Store the butter in a refrigerator maintained at a temperature of from 35° to 40° F.

After 12 hours or longer, if the butter is examined when it has been brought to a temperature of 45° to 50° F., it will not be brittle or crumbly. It may be slightly sticky, especially if it is worked quite dry, but it will have a fairly soft consistency and a good spreading property. It will find satisfactory consumer acceptance.

Comments Received Regarding Application of "50-45-40" Method.

Klamath Falls, Oregon:

"The '50-45-40' method of butter manufacture is proving very satisfactory under our fall and winter conditions."

R.W. Waggoner
October, 1947

Los Angeles, California:

"We have been using your original method during the fall season of the year, and have found it quite satisfactory."

G.H. Brockmeyer
December, 1943

Salt Lake City, Utah:

"We received this bulletin and, because of the very valuable information contained in it, we would very much like to obtain at least seven more copies for distribution among our various plants."

M.K. Rankin
January, 1943

Seattle, Washington:

"I am pleased to inform you that the station bulletin No. 414 entitled 'The 50-45-40 Method for Making Butter' which I requested you to send two copies to each of our 32 plants have been put to excellent use."
"First we sent out the summary of the bulletin which you had in one of your monthly reports by multigraphing copies of the report I received. Then we followed up with the bulletin about two weeks later. Shortly after that I made a trip to each plant and along with my other work inquired about the method to see how many were following it and all the plants had started using it.

"Some of them said that it was necessary to work butter much more and they didn't like that, but they had noticed how much brighter, more waxy and pliable the body was. They feel the extra working is worth the improved body condition and appearance.

"We feel the change over to the '50-45-40' method has not only improved the body but it seems to give an improved flavor to the butter, as well. Which only goes to prove body of butter has something to do with flavor condition. We have never stressed body too strongly in our grading in this country."

Arthur E. Groth
February, 1944

Portland, Oregon:

"If creameries in the dry hay feeding areas of the western United States will follow the methods of buttermaking recommended as result of this research, the annual savings made by these creameries will repay many times the expense incurred in doing the research.

"Our creameries have been following the pasteurizing and churning methods developed in this research project for the past two winters. The butter made during the winter months as result of following these methods has had much less tendency to crumbliness and stickiness than under any other method we know of. The butter has shown the minimum of leakiness in the print room to the definite financial benefit of the 8,000 dairy farm families who own this enterprise."

G. A. Brown
October, 1942

Philadelphia, Pennsylvania:

"Your operations are not unlike those we use for bringing about the most desirable crystallization of the fatty acid glycerides in cocoa butter. If improperly done, chocolate is likely to become crumbly and of poor texture."

Joseph R. Maxwell
March, 1944
Caldwell, Idaho:

"It seems that an increasing number of buttermakers throughout the Northwest are using the Oregon method of manufacturing butter during the winter months, and are more than pleased with the success they are having with it.

"I understand also that the ... Cooperative Creamery in Idaho here is using the '50-45-40' method this winter and having very good success.

"I have found that butter made under various other methods cannot compare with the Oregon method of manufacturing of butter in regard to body, texture and spreadability of butter; also in regard to leakiness and loss of moisture during cutting -- especially where automatic cutters are used."

R. W. Van Auker
January, 1945

Chicago, Illinois:

"You have done a great piece of research work on an economically, tremendously practical subject that has shown itself exasperatingly evasive in the past, in its reaction to scientific study. You have done an unusual job of digesting your experimental results. Your summary and conclusions are backed by a most convincing array of factual experimental results, and your directions of how to best utilize your findings to insure a pliable body with satisfactory spreadability constitute a real contribution to the Industry. My sincere congratulations to you.

"Frankly, I have read your bulletin with the greatest of interest and am convinced of the soundness of your conclusions and the merits of your '50-45-40' method and all the precautions that accompany it, for fall- and winter-made butter. There is only one suggestion that I can offer, and that is that the work be continued by switching to summer-made butter with a view to accomplishing proper firmness and standing-up property without sacrificing spreadability."

O. F. Hunsiker
April, 1943
Curing Cheese in Sealed Cans

The first attempts in this country to package Cheddar cheese appear to have been made by E. F. Pernot, bacteriologist at the Oregon Agricultural Experiment Station during the first few years of the present century. He used tin cans paraffined on the inside as containers for the cheese. The curd was placed directly into the cans and then pressed. After pressing covers were fitted on the cans and soldered, thus hermetically sealing the cans. He also placed curd in hoops in the regular manner and, after pressing, the bandage was removed and the cheese then slipped into cans, which were made to fit, and covers were immediately soldered on. Five-pound and 23-pound cheese were made in this manner.

Pernot stated that a good feature of canned cheese was the curing which obviated the constant care incident to the ordinary methods, for after the cans were placed in the curing room they required no further attention other than to keep the temperature low and constant. Humidity, dryness, vermin and mold could not affect it. He found that a satisfactory quality cheese was obtained when the product was cured at a constant temperature of 60°F. He pointed to the market demand for placing foods in sealed packages and for the smaller demand for food in bulk form as formerly. He felt that the sale of cheese would be increased if the product could be purchased in cans or packages upon which was marked its age and flavor; the latter being designated by letter or by name. He stated this could be accomplished by the use of pure culture and by curing the cheese in cans, or by some other means which would exclude the influence of undesirable bacteria.

Pernot apparently did not continue his project as there are no further records of any further research available in the experiment station files. If he had continued the experiments and had been successful in perfecting a practical method of packaging cheese, the cheese industry in the United States may have expanded enormously.

Canned Cheese Perfected

About a quarter of a century later, Rogers and associates of the Bureau of Dairy Industry, U. S. Department of Agriculture developed a method of packaging and curing cheese in a valve-vented can. With this method, developed carbon dioxide is permitted to pass to the outside of the can as this gas is produced during the ripening of the cheese. Since air will not enter the can, conditions for the growth of mold on the cheese are thus prevented.
They found that the increased cost of the cheese marketed this way was largely offset by the elimination of loss through evaporation, the necessity for paraffining, and the care of the cheese in the curing room.

With such types of cheese that cannot be ripened in cans, such as Swiss cheese, the blocks or wheels may first be ripened on shelves, then they may be cut into prints and placed in sealed cans or glass jars. Before sealing, however, it is necessary to displace the air around the cheese with a gas such as carbon dioxide or nitrogen in order to prevent the growth of mold.

In a U. S. Department of Agriculture circular, published April, 1935, Wilson gave full directions for packaging, curing, and merchandising American Cheddar cheese in valve-vented cans. Two types of cans were suggested: the round type for either 12-ounce, one-pound, or two-pound prints of cheese, and the five-pound oblong can for a loaf that can be cut into slices for sandwiches.

At the Oregon Agricultural Experiment Station in 1934 and 1935, Reynolds and Wilter tested this new method of packaging and curing of cheese as developed by the U. S. Department of Agriculture. Using the method of manufacture as suggested by Wilson, it was found that cheese of a good flavor and a fine body and texture was obtained when the cheese was cured for three months at a temperature of 50° to 60° F., or in six months when cured at 42° F. It was found that curing the cheese at temperatures above 60° F. was unsatisfactory. A preliminary experiment involving the curing of cheese in sealed glass jars from which the air was exhausted at the time of packing was also made. Although a slight swelling of the lids was observed, it was felt that this type of packaging and curing of cheese would have promise of practical application.

During the next several years Reynolds supervised the packaging and curing of several hundred thousand pounds of cheese, both in valve-vented cans and in vacuum-sealed cans in the plant of the Dairy Cooperative Association in Portland, Oregon. Cheese scoring regularly 92 to 94 was made and considerable success in the marketing of cheese in this form was attained until, as a result of World War II, cans were unobtainable.

Tests to determine the retail and household conditions of temperature necessary for vacuum-sealed cans of American Cheddar cheese to maintain the high quality when used were made by Golding at the State of Washington Agricultural Experiment Station. For the tests he obtained 24 vacuum-sealed cans of one-year-old high quality cheese representing six different batches of cheese made in the plant of the Dairy Cooperative Association, Portland. He concluded from his findings that, "High-quality, year-old, vacuum-canned, American Cheddar cheese to reach the consumers' table in fine condition should be held at 52° F. or below. If held at higher temperatures, around 70° F. for 50 days, gas will be produced and
the high quality of the cheese is spoiled. Long periods of holding at adverse conditions are much more objectionable than those of only a few days. There is little to be gained in producing fully-mature high-quality American Cheddar cheese if it is to be spoiled by high temperatures as in the retail store or household."

The New York State Agricultural Experiment Station studied methods to limit gas production in canned cheese. Dahlberg found that when the cheese was made from milk of the best sanitary quality, which had been properly pasteurized, gas production was low and the gas itself was almost pure carbon dioxide. After pressing the cheese, it was cut into a suitable size, wrapped in parchment paper, and placed in a can. A small parchment envelope containing about two grams powdered magnesium hydroxide (milk of magnesia) was placed on the parchment paper in which the cheese was wrapped. The can of cheese was then sealed under 25 inches of vacuum, and the cheese was ready to be placed on the shelf in the curing room at approximately 50°F. As carbon dioxide was developed, the magnesium hydroxide combined with it to form magnesium carbonate and water. The material in the envelope slowly hardened and remained white. Dahlberg stated, "In the first few days in the can the bacteria in the cheese utilized all available oxygen. Even if the cheese is sealed at atmospheric pressure, the can will develop a small vacuum. The purpose of vacuum packing is to remove the air from the can, especially the inert gas nitrogen, thereby creating a vacuum in the can to hold some of the carbon dioxide liberated from the cheese. In the absence of oxygen and in the presence of much carbon dioxide there is no mold growth. When cheese is vacuum packed it will not develop a gas pressure within three to six months, or longer, and most cheese is consumed within this period. However, when magnesium hydroxide is present, there will be no gas pressure for several years. Actually, gas pressure in canned cheese does not indicate spoilage, but consumers know that gas pressure in other canned foods does mean spoiled food. Thus it is essential to prevent gas pressure in canned cheese to obtain consumer acceptance."

Packaging Cheese in Transparent Film

Although Pernot, in his bulletin published in 1904, predicted the merchandising of cheese in cans or packages, very little progress was made until very recently in marketing natural cheese in the package form. Cheddar cheese has invariably been marketed in the form of the customary 22- to 24-pound round Daisy or Triplet form, cloth covered and paraffined, from which wedges are cut by the retail merchants.

Considerable progress has been made, however, in the merchandising of process cheese in convenient, attractive packages. During the year 1939 a total of 236 million pounds of process cheese was manufactured, in accordance with the U. S. Census of Manufactures.
A considerable interest in the merchandising of rindless natural cheese in half-pound, one-pound, or larger sizes, in either transparent or nontransparent wrapping material, has developed since World War II. We are at the threshold of a considerable development in the field of merchandising of natural Cheddar cheese. One authority recently remarked to the author that the orthodox, paraffined Daisy or Triplet size cheese would disappear from the market within the next ten years.

Several manufacturers of cheese in the Pacific Northwest are now marketing limited amounts of rindless natural cheese. Among these may be mentioned Whatcom County Dairymen's Association at Lynden, Washington; Clark County Dairymen's Association, Battle-ground, Washington; Dairy Cooperative Association, Portland; and Tillamook County Creamery Association, which operates sixteen plants in Tillamook County. Recently Mr. Lawson, manager of the Tillamook association, commented, "There is still much room for improvement in Cheddar cheese packaging. The small type of cheese package provides greater convenience and increases consumer acceptance. The added cost incident to packaging can be offset by lack of waste from dryness and trim. Natural cheese is inherently subject to mold, which in practically all cases is harmless, but wasteful. The Cheddar cheese industry is devoting extensive research to the problem in connection with the manufacture and merchandising of the rindless package. The quality of cheese for rindless packaging must be select to begin with if the best results in flavor and elimination of mold are to be attained."

In a recent bulletin by the Bureau of Agricultural Economics, U. S. Department of Agriculture, entitled "Postwar Packages and Containers for Marketing Foods," it was pointed out that new types of containers and packages and materials for their construction are in prospect for postwar food marketing. It was pointed out that technological advances in this field have been rapid in recent years, and experiences of the war period in packing for military purposes will be applicable to packaging for civilian use when materials and labor become available. It was predicted that the effects of these changes in packaging were likely to extend beyond the food marketing processes to other aspects of our economic life.

In discussing the flexible sheet packaging material for food products, the author of the bulletin, D. R. French, stated, that there are three common types of such material; paper, transparent film, and metal foil. He discussed these as follows: "Paper, in the form of kraft wrapping paper and bags, has long been widely used and it will continue to be important in the grocery trade. Vegetable parchment has long served as the wrapper for butter and is used successfully as the wrapper for fresh vegetables where tensile strength must be retained when the paper is wet. Glassine is a water-impregnated paper, transparent with a shiny surface. It is resistant to grease but it can be treated with lacquer to make it even more resistant to grease, water vapor, gas, and odors, and to make it
sealable with heat. The transparent plastic films which have given excellent protection to food and metallic equipment shipped overseas during the war, are likely to find greatly increased use in postwar marketing of food. The three general types of these films have many characteristics in common. They are transparent, resistant to grease, generally odorless and tasteless, and maintain their flexibility under extremes of temperature. Cellulose films are not all moisture-vapor-proof in single sheet form. This moisture permeability is desirable in wrapping fresh products as it permits the passage of carbon dioxide and of moisture-vapor which would otherwise cloud the inner surface of the film. The vinyl films and the rubber-base films both have high resistance to moisture vapor. This makes them excellent wrappers for substances needing such protection. Metal foils are likely to be more widely used in food packaging now that the war is over. They offer many of the protective qualities of the plastic film. In addition they are light-proof and have a decorative metallic brightness to offset, for some products, the disadvantage of opaqueness. In the above mentioned bulletin are listed the quantity of materials used in packaging farm-food products during the year 1944. For dairy products were used:

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawed lumber</td>
<td>27,312,000 board feet</td>
</tr>
<tr>
<td>Veneer</td>
<td>10,189,000 board feet</td>
</tr>
<tr>
<td>Paperboard</td>
<td>156,744 tons</td>
</tr>
<tr>
<td>Paper</td>
<td>273,013 tons</td>
</tr>
<tr>
<td>Steel</td>
<td>372,078 tons</td>
</tr>
<tr>
<td>Glass</td>
<td>4,335,000 gross</td>
</tr>
</tbody>
</table>

At the present time, three methods of wrapping small prints of natural Cheddar cheese without rind in transparent films are used. "Pliofilm" is used in one method. The film is a trade-marked product of the Goodyear Tire and Rubber Company. With another method is used "Parakote." This wrapper is protected by patents held by the Marathon Corporation. With the third method is used "Flex-Vac," sold by the Standard Cap and Seal Company.

Packaging Cheese in Pliofilm*

The curd when ready is weighed out accurately into a square, metal hoop. Place approximately 21 pounds 7 ounces of curd into each hoop.

This discussion is based on description of process given in a mimeographed bulletin, "How to Cure and Package Natural Cheddar cheese in Pliofilm" the Goodyear Tire and Rubber Co., Inc., 1945, and on special communication to the author by L. H. Jones, Packaging Supply Co., Kaukauna, Wisconsin.
After 45 minutes of pressing, the blocks of curd are weighed and the weight correctly adjusted so that each block weighs 20 pounds 10 ounces. The cheese is then dressed using unbleached muslin. Inside dimensions of the hoop are 14 inches by 11 inches by 3 1/4 inches deep. The cheese is pressed overnight using uniform continuous pressure.

The next morning the cheese is ready for wrapping in Pliofilm (40 GA NI 0.0004 inch thick). One at a time the blocks of cheese should be relieved of the all-over cloth and wrapped in Pliofilm so that no time for drying is allowed. Two sheets of wrapping material are made ready. The first is a sheet of 30 pounds bleached glassine. (Another paper has been recommended for this purpose; it is called Orange Supercalendered MG, and is essentially a one side waxed paper, glazed on the other side. The paper is applied with the wax side next to the Pliofilm and the glazed side out. This affords better adhesion of Scotch tape in fixing the wrapper, and the wax inside is additional greaseproofness for box protection in cases where the curing block exudes fat.) The paper is laid out on the wrapping table. On top of it is placed a sheet of 40 gauge NI Pliofilm 20 inches by 31 inches in size. The block of cheese is then placed on the Pliofilm wrapper and the wrap is made and fastened in place with short strips of Scotch tape 1/4 inch wide. Immediately thereafter, the glassine is used to overwrap the Pliofilm wrapped square and the glassine wrap in turn is also held in place with short strips of Scotch tape. The resulting double wrapped block is then turned bottom side up and is ready for boxing.

A newly designed curing box has been found better adapted especially where the cheese is to be sent to a central packaging depot. The box is similar to the one used formerly but is deeper providing for use of a heavier and deeper cover. The new cover is 3/8 inch thick. This is not nailed onto the box but is pressed into the boxes when the cheese is stacked. The thicker cover has less tendency to become disarranged and generally fits in a box better. It stays level better. The inside depth of the box is 3 5/8 inches to provide for the thicker cover. Slats across the covers are placed 2 inches away from the ends and these slats are 1 1/2 or 1 3/8 inches wide.

To prepare the pack, the box is inverted above the double-wrapped square of cheese which has been turned over, and lowered to enclose the wrapped package. The box is then turned right side up and the slip-in cover is placed on top of the cheese. The three slats are then spaced properly over the slip-in cover and are nailed to the thick ends of the box, drawing down the slip-in cover to squeeze all air from the unsealed package within the box. Care should be taken to see that the grain, when slip-in covers are wood, is running the direction of the short dimension to bring it at right angles to that of the three slats.
Pressure is now required for a period of at least two days. Pressure is obtained by stacking one box on top of the other. The position of the two top boxes must be reversed every six hours so that the very top box receives its share of pressure. The cheese should be held at a minimum temperature of 80°F for two days.

After this pressing, the cheese is now ready to be placed in the curing room. The temperature should be maintained at approximately 45°F. It should not be below 40°F or above 50°F. When cheese is made from high quality milk that has been pasteurized, and when the manufacturing method has been satisfactory, cheese can be cured satisfactorily at 45°F. Moisture evaporation from the cheese is negligible.

The length of time for curing may be varied. If a mild flavor is desired, about two months would be sufficient, whereas if a fuller flavor is desired, from four to six months would be required.

After curing, and before the boxes of cheese are cut into prints, it is necessary to place the boxes of cheese in a room at 75°F to 80°F for a warming-up treatment. The boxes of cheese should be stacked to permit air circulation between them. Usually 24 hours or 48 hours in this room are sufficient to temper the cheese.

The boxes, when removed from the tempering room are placed one at a time on a table where the slats and the slip-in covers are removed. The cheese is taken from the box and the outer wrap is removed. The wooden boxes may be reused.

The Pliofilm wrap is now removed and the block of cheese is placed on a cutter for cutting into the desired size of either one-half, one-, two-, or five-pound prints. The weight of the prints should be checked and should be adjusted so that it is accurate.

As soon as the cutting has been completed, the cheese is removed from the cutter in four sections of five pounds each. The sections are assembled on simple platforms, with skid runner bottoms, in the same relation to each other as previously existed in the uncut square. Each print is then wrapped with 40 gauge NI Pliofilm.

The amount of Pliofilm necessary depends on the size of the print. For one-half pound prints, one pound Pliofilm is sufficient for 500 pounds, and for 1-pound size prints one pound is sufficient for 640 pounds.

The Pliofilm is quickly and easily applied. No seal is made but the creases are set in the folds by sliding the wrapped print on the table top for an inch or so as the operator finishes the end folds. As each print is wrapped, it is placed on a second tray in the identical relationship to its neighboring prints that it bore
on the first tray and in the original square.

For an outer wrap is used 80 gauge untensilized film which possesses the qualities desired in an outer wrap:

1. It remains smooth -- does not wrinkle.
2. It clings to the inner wrap and thus to product.
3. Has high brilliance and easy printability and adds sales appeal.

The outer wrappers are sealed but not in the regular sense of the term. No attempt is made to seal the initial lap from edge to edge. The cheese print is actually $3\frac{1}{2}$ inches wide where this seal is made and a 2-inch wide stationary sealing bar makes the seal. Then the end folds are sealed lightly, quick contact with the sealing plates being used only to insure retention of the folds. Do not seal the package airtight. When being pressure packed later, it is desirable to expel the trapped air from packages. This is possible without rupture of the wrapper provided the package was previously only partially sealed. There is another highly important reason for care in sealing. Too high temperature shrinks the 40 gauge Pliofilm inner wrapper. When this occurs it is generally disastrous because the tendency to shrink is so great that rupture of the film results. Then the cheese molds.

The finished packages would mold within a few days if nothing further were done to prevent it. Therefore, the necessity of the next step -- the pressure pack. A tray accommodates 20 one-half pound packaged units. Over the top of these 20 packages is placed one of the 10-pound size die-out sheets. A metal sleeve is pressed down around this assembly. A box is inverted above and lowered to encircle all four corner posts until the box comes to rest on the posts. These should extend two inches above the sleeve body proper. The cheese is then pressure packed as has previously been discussed. Stein recommends holding the cheese in the warm room a minimum of 36 hours. It is then stored in a refrigerator for not less than 24 hours before it is shipped.

A more recent development is the use of a fibre-board box for 10 pounds of the finished wrapped cheese. At first the sleeve type carton was used, but this is gradually being displaced by the lower-priced carton which is glued and held under pressure during the setting of the glue. Equipment for handling these boxes is now available.

It has been reported that there is a possibility of the development of wrapping machines. The use of these would cut down the high cost of hand wrapping natural cheese. It has also been reported that the manufacturer of Pliofilm is planning to develop a suitable film that can be used for packaging as a single wrapper to out-mode the present double-wrapper system. With reference to the slight
oiling off which takes place when the cheese is held at from 70°
to 80 ° F., Mr. Jones in a letter to the writer had the following
comments to make, "While the slight oiling out of cheese has been
found beneficial generally without too great detriment in the pack-
aging of natural Cheddar cheese in Pliofilm, it has never been
made the subject of worthy study till your present interest so far
as I know of, and for that reason there is little to say of depend-
able data that can be furnished as yet. We have found that just
the right amount of grease on the surface where 40 Gauge Pliofilm
is applied is greatly to be desired. Too much is not too good and
sometimes results in slight rancidity. We might say that hardly
too little can be brought out if any at all is produced on the
surface, for the slightest oiling does the work required. Heavy
oil is not necessary. When 40 Gauge tensilized film is applied,
the grease on the cheese surface does several things, namely:

(1) Aids in hand wrapping operations.
(2) Increases clinging of film to cheese.
(3) Smothers mold development -- Probably proportionately.
(4) Aids in air removal in pressure-packing.

"Packing plant operators are steadily finding out what is
desired in the volume of fat on the surface and are generally
observant in their production program of what temperature and for
what time it is necessary to produce the desired effect. Generally
it has become a matter of experience and constant study and observa-
tion. I wish there were more definitely something I could report
on this, as I realize this leaves it all very vague."

Cost of Wrapping Cheese in Pliofilm

Based on the use of semi-automatic equipment and using the
methods previously described, the costs have been estimated as
follows during 1945.

<table>
<thead>
<tr>
<th>Size of Package</th>
<th>1/2 lb.</th>
<th>1 lb.</th>
<th>2 lb.</th>
<th>5 lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Wrap</td>
<td>.23</td>
<td>.18</td>
<td>.136</td>
<td>.103</td>
</tr>
<tr>
<td>Outer Wrap</td>
<td>.766</td>
<td>.687</td>
<td>.407</td>
<td>.13</td>
</tr>
<tr>
<td>(2-color printed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>1.25</td>
<td>1.00</td>
<td>.75</td>
<td>.60</td>
</tr>
<tr>
<td>Fibre Carton</td>
<td>.63</td>
<td>.63</td>
<td>.63</td>
<td>.63</td>
</tr>
<tr>
<td>10 lb. size</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Total 4 items</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost per lb. cheese</td>
<td>2.876¢</td>
<td>2.397¢</td>
<td>1.923¢</td>
<td>1.463¢</td>
</tr>
</tbody>
</table>
Parakote Method*

When the Parakote wrapper is used for cheese, the following method is used.

The standard Wilson 20\(\frac{1}{2}\) rectangular hoops are utilized for this pressing operation. Two press cloths, which have been soaked in a brine solution (to provide easy removal later on), each measuring approximately 11" x 14" are made available. Place one press cloth in the bottom of the hoop and distribute the curd (21.4 lbs.) in the hoop. Spread the curd evenly, especially in the corners and along the sides of the hoop. Next, place the second press cloth over the curd and put the hoop cover in place. Then, place the hoop in a standard cheese press under full pressure. Be sure that the hoop is "square" in the press so that a uniform rectangular shape will result.

After about one to two hours in the press, take the hoop out. Remove the square of pressed curd, place it on a work table and strip off the rough pressing cloths. Cut it in half lengthwise with the blade cutter and place a metal separator 3\(\frac{1}{4}\)" x 14", wrapped in brine-soaked cloth, in the cut. Then wrap the two 10 lb. squares as one unit in a brine-soaked cloth.

Fit the sleeve of the hoop around the entire unit and slip the hoop over the sleeve. Next, turn the entire assembly right-side up and put the hoop cover in place. Again, place the hoop in the press. This time allow it to remain under full pressure for a minimum of three hours. Then remove the hoop from the press and strip off the pressing cloths from each 10 lb. print and then they are ready to be wrapped in a Marathon Parakote natural cheese wrapper.

Peel two 21" x 21" Parakote wrappers from their accompanying slip sheets and lay coated side up on the work table. (The slip sheet of embossed stock is provided to prevent blocking of wrappers in transit in storage and is not used in the packaging operation except as a possible overwrap for the Parakote package.) Place each 10 pound square on its Parakote wrapper, carefully centering each square on the individual wrapper. Then, proceed with the actual wrapping.

The resulting Parakote wrapped squares are then overwrapped with the slip sheet which originally came with the wrapper and both 10 pound squares are returned to the hoop and the original metal separator (this time without a press cloth wrapping) is placed between them. Place the hoop into the press and allow it to remain that way under full pressure overnight. At this point, warm water

* From memorandum prepared by Marathon Corporation, Menasha, Wisconsin.
may be poured over the hoop to bring the surface temperature of the hoop up to 100° - 105° F., which helps insure a good seal with the Parakote wrapper. The plastic characteristics of the cheese and wrapper respond more readily to a moderately high temperature condition during the final pressing operation. This heat factor plus the pressure of the hoop insures a good seal with the Parakote wrapper and the pressure of the press helps in forcing air out of the wrapped square before the seal is completed. Packaging tests and factory conditions determine whether a high room temperature or the use of warm water or steam is more adaptable for the final pressing operation.

The next morning, remove the squares from the hoop. Leav- ing the squares overwrapped with the white slip sheet, place them in a container (either wood, fiber, or corrugated) measuring 3½" x 14" x 11-1/8" (inside dimensions). The containers may then be stor- ed in the curing room and the process is complete.

Five-pound, 2½-pound, 2-pound, or 1-pound units can easily be made by altering the cutting process previously described and by using different sized metal separators in the hoop during the last two pressing operations.

In a communication to the writer under date of September 23, 1947, Mr. J. R. McNeVins, of the Marathon Corporation stated that Parakote has been used successfully in packaging a close surface natural cheese as it allows the cheese to become aged in the wrapper, and inedible rind is eliminated. He stated that the coating has been developed to permit moistureproofness, film strength, and heat-sealing qualities, and this has been added to the fine transparency and strength of two laminated sheets of cellophane. He stated that the price of the Parakote wrapper ranges from approximately $50.00 per thousand for 5 pound wrappers to approximately $80.00 per thousand for the 10 pound size.

**Flex-Vac Method**

"The laminated film is supplied to the user in bag form. The bags are made up to the correct dimensions to fit fairly snugly on the cheese cuts. It is necessary that the cheese be cut in uniform size pieces so that they will fit properly into the bags.

"The cheese is placed into the bag with the aid of a loading device. The bags are opened to the proper dimensions by an expanding mandrel and the cheese is then propelled into the bags by a plunger.

"The loaded bags are then placed into pockets of the Flex-Vac vacuuming machine and rotated up under the vacuum head. The present size machine can accommodate three units at a time under the head. A vacuum of approximately thirty inches is drawn in the chamber and the bags are then sealed off by a heat sealing bar. The bags are then given a final inspection, preferably at the end of one half hour and are then packed into the shipping cases.

"It is possible to print this laminated film in attractive multi-colored label designs.

"The bags and equipment are available through the Standard Cap and Seal Corporation. The machinery is available on a rental basis."

In the opinion of Mr. R. W. Stein, of the Dairy Cooperative Association, Portland, within a few years most of the natural Cheddar cheese for retail sale will be sold in the packaged form. He foresees considerable modification in the present methods of film wrapping of cheese. The process will be streamlined and automatic wrapping machinery will be introduced. The problem of mold control must be given more study as it may be necessary for the cheese factories to make cheese that is "free from mold spores," he stated.

RECENT ADVANCES AND FUTURE OPPORTUNITIES
IN THE CHEESE INDUSTRY

The amount of cheese consumed in the United States has increased in recent years but the average per capita consumption of the product is still quite small. During 1946 the average daily consumption of cheese, excluding cottage, was only 0.28 ounce per day or 6.9 pounds for the year.

The production of all cheese, except cottage, increased during the ten-year period, 1937-1946, from 648,825,000 to 1,099,200,000 pounds, or 69 per cent. The production of cottage cheese increased during the same period from 132,355,000 pounds to 248,800,000 pounds, or 86 per cent. The U. S. per capita consumption of all cheese, except cottage, increased from 5.5 pounds during 1937 to 6.9 pounds during 1946 and was estimated to be 7.2 pounds during 1947. Consumption of cottage cheese increased from one pound in 1937 to one and a half pound per person in 1946.

Exports of cheese increased, and imports decreased during the war and post-war years.
When the amount of the different varieties of cheese manufactured during 1937 and 1946 are compared it is seen that the production of American Cheddar cheese increased 60 per cent and considerable increases took place in Italian, cream and Neufohatel, blue-mold and miscellaneous varieties. The production of cottage cheese nearly doubled. Of all cheese produced during 1946, 62 per cent was of the Cheddar variety.

The increase in blue-mold cheese manufactured in the United States is of interest. During 1937 none of this variety was of domestic production and only 2 million pounds were imported. During 1946 very little blue-mold cheese was imported but 12½ million pounds were manufactured in this country.

Now if you forget all these figures, just remember that production of cheese in the United States has increased greatly in the past 10 years and that consumption increased by a third but heavy exports and army use were a big factor in disposing of the larger output.

We eat cheese because we enjoy eating it. We like the color, the aroma, and the flavor of the many varieties of cheese that are available in food stores. Nearly everybody likes well-ripened, fine-flavored, waxy-bodied Cheddar cheese. Many people enjoy the piquant flavored, firm-bodied Parmesan and Romano cheeses. If we like a soft variety that has a more pronounced flavor, Limburger or Camembert cheese are available. Or we can choose a medium-hard cheese as brick or Roquefort.

A large number of "natural" varieties of cheese are available and, in addition, cheese which has been "processed", grated, comminuted, as well as cheese foods and spreads, are being marketed.
### Cheese Production in the United States

<table>
<thead>
<tr>
<th></th>
<th>Pounds 1937</th>
<th>% of Total</th>
<th>Pounds 1946</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>American</td>
<td>492,041,000</td>
<td>75.8</td>
<td>801,177,000</td>
<td>72.9</td>
</tr>
<tr>
<td>Part Skim</td>
<td>4,794,000</td>
<td>0.7</td>
<td>2,655,000</td>
<td>0.2</td>
</tr>
<tr>
<td>Swiss</td>
<td>41,504,000</td>
<td>6.4</td>
<td>55,030,000</td>
<td>5.0</td>
</tr>
<tr>
<td>Munster</td>
<td>7,450,000</td>
<td>1.2</td>
<td>9,235,000</td>
<td>0.8</td>
</tr>
<tr>
<td>Brick</td>
<td>23,193,000</td>
<td>3.8</td>
<td>8,443,000</td>
<td>0.8</td>
</tr>
<tr>
<td>Limburger</td>
<td>8,165,000</td>
<td>1.3</td>
<td>9,548,000</td>
<td>0.9</td>
</tr>
<tr>
<td>Italian</td>
<td>13,520,000</td>
<td>2.1</td>
<td>74,926,000</td>
<td>6.8</td>
</tr>
<tr>
<td>Cream</td>
<td>43,987,000</td>
<td>6.8</td>
<td>65,630,000</td>
<td>6.0</td>
</tr>
<tr>
<td>Neufchatel</td>
<td>---</td>
<td>---</td>
<td>7,226,000</td>
<td>0.7</td>
</tr>
<tr>
<td>Blue Mold</td>
<td>---</td>
<td>---</td>
<td>12,604,000</td>
<td>1.1</td>
</tr>
<tr>
<td>All other varieties</td>
<td>9,171,000</td>
<td>1.4</td>
<td>52,786,000</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>648,825,000</td>
<td></td>
<td>1,099,200,000</td>
<td></td>
</tr>
</tbody>
</table>

Cottage Cheese curd 132,355,000

---

### How the 1937 and 1946 U.S. Milk Supply Was Used

<table>
<thead>
<tr>
<th></th>
<th>1937</th>
<th>1946</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Milk Produced:</strong></td>
<td>105,958,000,000</td>
<td>122,556,000,000 lbs.</td>
</tr>
<tr>
<td>Fluid Milk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used in Cities and Villages</td>
<td>30.48</td>
<td>39.2</td>
</tr>
<tr>
<td>Used on Farms where produced</td>
<td>11.96</td>
<td>10.0</td>
</tr>
<tr>
<td>Butter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creamery Butter</td>
<td>30.65</td>
<td>18.7</td>
</tr>
<tr>
<td>Farm Butter</td>
<td>9.70</td>
<td>5.4</td>
</tr>
<tr>
<td>Cheese</td>
<td>6.12</td>
<td>8.8</td>
</tr>
<tr>
<td>Evaporated &amp; Condensed Milk</td>
<td>4.34</td>
<td>6.0</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>3.13</td>
<td>6.9</td>
</tr>
<tr>
<td>Fed to Calves on Farms</td>
<td>2.61</td>
<td>2.7</td>
</tr>
<tr>
<td>Dried Milk</td>
<td>0.10</td>
<td>1.3</td>
</tr>
<tr>
<td>Other Used</td>
<td>0.90</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Cheese

U. S. Production - Export and Import - Consumption

<table>
<thead>
<tr>
<th></th>
<th>1937</th>
<th>1946</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lbs.</td>
<td>lbs.</td>
<td>%</td>
</tr>
<tr>
<td>Production (All varieties except cottage)</td>
<td>648,825,000</td>
<td>1,099,200,000</td>
<td>69</td>
</tr>
<tr>
<td>Imported</td>
<td>55,490,000</td>
<td>20,800,000</td>
<td>63 (decrease)</td>
</tr>
<tr>
<td>Exported</td>
<td>1,336,000</td>
<td>186,000,000</td>
<td></td>
</tr>
<tr>
<td>Production (Cottage)</td>
<td>132,355,000</td>
<td>248,800,000</td>
<td>88</td>
</tr>
<tr>
<td>Consumption Per Capita (excluding cottage)</td>
<td>5.5</td>
<td>6.9</td>
<td>25</td>
</tr>
<tr>
<td>Consumption (all cheese)</td>
<td>6.5</td>
<td>8.6</td>
<td>32</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Agriculture.

Why Has the Consumption of Cheese Increased?

The better buying power of the American people during recent years, shortage of meats, the availability of more U. S. made varieties of cheese, more cheese sold in convenient size packages, improved merchandising methods, including the introduction of attractive refrigerated display cases, and magazine and radio advertising are the factors that have chiefly been responsible for increased sales of cheese. Results from technological research have also been a factor.

Statistics show that when the consumer income increases there is an accompanying increase in the consumption of all dairy products, including cheese. City people consume considerably more cheese than rural people. The following data show the per capita consumption of cheese by income level in the United States during 1941. Consumption more than doubled from the low income to the high income group.
Per Capita Consumption of Cheese
by income levels.

<table>
<thead>
<tr>
<th>Income Level</th>
<th>Under $500</th>
<th>$500-$999</th>
<th>$1,000-$1,499</th>
<th>$1,500-$1,999</th>
<th>$2,000-$2,999</th>
<th>$3,000-$4,999</th>
<th>$5,000 and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbs.</td>
<td>1.8</td>
<td>2.7</td>
<td>4.7</td>
<td>6.4</td>
<td>6.4</td>
<td>6.5</td>
<td>6.8</td>
</tr>
<tr>
<td>FARM FAMILIES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lbs.</td>
<td>5.3</td>
<td>6.1</td>
<td>7.1</td>
<td>8.6</td>
<td>9.7</td>
<td>10.4</td>
<td>11.4</td>
</tr>
<tr>
<td>NONFARM FAMILIES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: U. S. Department of Agriculture.

In this connection it should be considered that a high rate of employment means well-filled lunchpails and also the sale of many sandwiches at lunch counters. Cheese has been used to a large extent for lunches and for sandwiches.

Colorful full-page advertisements in newspapers and magazines, radio programs with advertising, educational literature, and demonstrations, have been factors in telling the consumer about cheese. It has been emphasized that cheese can be used in many ways. It can be eaten with a number of other foods such as with crackers, bread, fruit, vegetables, macaroni, pie and soup, and it has many uses in cookery. Well ripened cheese when served as a pre-dinner appetizer is greatly enjoyed by connoisseurs.

Distributors of processed cheese have aggressively promoted by means of advertising, efficient distribution, and modern merchandising, the sale of many varieties of cheese foods in small containers. This has greatly increased the popularity of cheese.

Cheese was used extensively in the ration of the armed forces. Cheese was considered an essential item of food during World War II and the U. S. Government requested the cheese industry to increase the output of cheese. This was a great factor in popularizing cheese among millions of men and women. Observations in Canada during the war showed that consumption of cheese by the Canadian soldier increased when first grade quality, well-ripened cheese was part of the ration.
All cheese purchased for Lend-Lease was graded by government graders. This resulted in a gradual improvement in the quality of the cheese manufactured and the effect of this improvement has been maintained since the discontinuance of the Lend-Lease program. The improvement and standardization of quality have increased sales.

A large factor in increasing the sale of cheese has been the modernization and establishment of dairy departments in food stores and the wide use of attractive "reach in" refrigerated display cases. Distributors of cheese have reported that when a retailer takes his cheese out of a side-wall refrigerator and displays it in a modern open case, sales of cheese have increased up to 300 or 400 per cent. Cheese is still an "impulse item" instead of a "habit buying item" with many people. If many varieties of attractively packaged cheese are displayed in a well-lighted refrigerated case many people who did not plan to purchase cheese may select several packages. It has been reported that one large food chain is now getting 18 per cent of its gross volume from its dairy counters.

Merchandising natural cheese by cutting off wedges from a wheel of cheese at the time of sale is a thing of the past. The modern method is to sell either pre-weighed portions of cheese wrapped in transparent film, or 4-ounce to 5-pound portions which have been packed in glass, tin cans, or transparent film in the cheese factory or central warehouse. The sale of cheese in individual packages has been a major factor in increasing sales and it is likely that cheese sales will be materially stimulated in the future by further improvement in packaging. The purchaser likes the availability, visibility, and economy of rindless cheese in transparent film.

Neat, attractive displays of varieties of cheese appeal to the public and attract their attention as well as stimulate their appetites for cheese.

Education of the retailer in methods of caring for cheese in the store, cutting bulk cheese, and wrapping the individual portions, and the reduction of waste has been a program of a number of cheese distributors. Attractive, illustrated booklets and sales manuals which describe how different varieties of cheese are manufactured and cured and how the cheese may best be merchandised have been distributed among retailers.

Technological research has been a factor in increased cheese sales, but only to a smaller extent. Scientific development in the cheese industry has been lacking. In general the present manufacture of cheese is similar to what it was 40 or 50 years ago. To be sure, there has been some development but cheesemaking is still pretty much an art and it requires a considerable amount of manual work and a long working day to make a batch of cheese. There has been improvement in the rennet and starter used in cheese manufacture.
and, with the introduction of pasteurization during recent years, the method of manufacture of Cheddar cheese has been standardized through educational work done by the Bureau of Dairy Industry and by others.

Many cheesemakers have known the "hows" but not the "whys" of cheesemaking. Without the proper application of science to cheesemaking, progress is slow. There has been a lack of team work between the cheesemaker and the scientist during the past, much to the detriment of the industry. Under the leadership of national organizations the industry is now taking hold of scientific developments. An important factor in technological development is the construction of larger manufacturing units properly manned with trained persons and equipped to produce an adequate amount of steam and having facilities for maintaining the desired temperature and humidity as well as for mold control in curing rooms.

An illustration of how the application of research findings to practical manufacture has been followed by increased sales may be given. The Geneva method of manufacturing cream cheese was demonstrated in 1926 and information regarding the process was given to the industry in 1927. From an output in the state of New York of 8 million pounds of cream cheese during 1926, the production increased to 21 million pounds in 1930. The increase was attributed to (1) the shorter and more certain procedure, (2) the method being especially adapted to a variety of flavors, (3) the improved keeping quality of the product, (4) the appeal which the cheese makes to consumers, (5) the very prompt and active adaptation of the method to commercial use by a few manufacturers, and (6) the general promotion of all types of cream cheese by manufacturers.

An example of the application of results from technological research is given in a recent University of Wisconsin bulletin. In this is outlined a routine procedure for the manufacture of Cheddar cheese which utilizes a controlled acid development in terms of time and acidity developed which uses directly the findings of research in related fields, mainly those of the results of pasteurization and acidity studies as reported by a number of research workers. The method outlined in the bulletin is widely used when manufacturing cheese from pasteurized milk.

The marked expansion of the blue-mold cheese industry in the United States was possible only because of the application of the findings from technological research.

Sometimes the results from research are not so quickly adopted by the industry. It was at the beginning of the present century when an Oregon research worker developed a method of curing rindless cheese in cans. This method did not find application in industry for many years.

The cheese industry cannot continue to develop along sound lines unless milk used for cheese is clean and is obtained from
healthy cows. The quality of milk used for cheese should be equivalent to that used for city milk consumption. Clarification, filtration, and pasteurization are definitely not processes that can substitute for sanitary production methods and proper cooling of milk on the dairy farms.

Pasteurization of milk is gradually being adopted by the industry as a public health measure to increase the safety of cheese as a food and to enable the cheesemaker to manufacture cheese of more uniform quality. All milk used for cottage and cream cheese is pasteurized and a large percentage of the milk used for Cheddar cheese is now being pasteurized. Research is under way to determine if it will be possible to make Swiss, Limburger, blue-mold, and other varieties of cheese from pasteurized milk. One large organization has reported that it is successfully manufacturing Camembert, Limburger, and other varieties from pasteurized milk. The cheese industry cannot risk the adverse publicity which follows reports by health departments that cheese is the cause of an outbreak of disease.

The use of the phosphatase test by regulatory agencies to determine if the milk used for a particular dairy product has been adequately pasteurized is of considerable importance from a public health standpoint. Of course, even though the milk has been adequately pasteurized, this does not preclude that the product manufactured may not contain pathogenic bacteria. If the water used in the cheese factory is contaminated with pathogenic bacteria, if diseased persons are handling the milk and curd in the cheese factory, or if the cheese is contaminated by insects or rodents, there is a possibility of infection. The test is, nevertheless, of great value.

In the mind of the consumer, cheese is a nutritious food. It was not until recent years that the average consumer came to realize more fully that cheese is a very valuable food. Information has not been generally available for consumers, however, with respect to the several nutrients that are present in cheese. They know in a general way that cheese (such as American Cheese) contains some fat and protein. They do not know how much of each is present in cheese as packages containing cheese do not generally show the composition of the product. Some people incorrectly believe that cheese is difficult to digest. They may associate a tough, corky-bodied cheese with poor digestibility. The recently published Dairy Council bulletin on cheese fills a long-felt need for a concise treatise regarding cheese and its nutritional value. The dissemination of the information given in the bulletin regarding the nutrient content of cheese and the value of cheese as a food will result in an increase in cheese consumption.

To sum up, I would say that while the consumption of cheese in the United States has shown a marked increase in the past 10 years, this increase has come about more through better merchandising, in-
creased consumer income, and scarcity of competing foods than it has through fundamental improvement in the product.

Cheese has been improved to some extent, but in general the cheese industry has been the slowest among the manufacturers of dairy products to adapt technological research results to manufacturing methods and fundamental quality improvement. If recent gains are to be maintained and new advances made it will behoove the industry to make full use of the findings of science both to improve the product and to assure the public that cheese is a safe, wholesome and nutritious food easily available at all times for a wide variety of uses.

LOOKING INTO THE FUTURE

In the light of developments that have taken place in the cheese industry in the past it would seem timely to consider the plans for the future. Should greater or lesser emphasis be on technological research, packaging methods, merchandising methods, public health safeguards, etc., than during the past?

There is an opportunity to improve all phases of the cheese industry - the production of milk, manufacturing, ripening, packaging, and marketing of cheese. Some people feel that improvement in the milk supply is most important; others feel that improvement in packaging deserves the greatest emphasis. The consensus seems to be that in a long-time program most emphasis should be given to IMPROVING THE MANUFACTURING AND RIPENING PROCESSES OF THE CHEESE.

The opinion that milk for cheese should be of equivalent grade as that used for market milk purpose is widespread. This opinion is shared by cheese factory operators who have adopted pasteurization of milk for cheese manufacture. The standards for production should be based on reasonable and sensible requirements.

It has properly been pointed out that the industry has not been able to arrive at the proper approach to the milk producers. Whenever it is able to do so, the milk quality improvement program will make rapid strides. What is needed is an effective milk grading program in each state. In the market milk industry milk that does not meet a certain grade standard must not be used. Such a quality program calls for state licensed persons doing the grading for flavor, cleanliness, and bacterial content of the milk. The only way to obtain real improvement in milk quality, in the opinion of some people is "to hit a man's heart through his pocketbook." A certain amount of educational work with the producers is, of course, necessary and advisable.

The following illustrates what can be accomplished through a vigorous milk quality improvement program. A cheese factory in the Pacific Northwest, before it launched an improvement program, received
milk which contained from 0.18 to 0.20 per cent acid. After two years of improvement work the milk averaged 0.14 to 0.15 per cent acid and much of the volume of milk received was used for Grade A bottled milk.

It is appropriate to consider in the program of improving the milk supply also the method of collecting the milk from the farms. It is also important to consider the sanitation of the cheese factories. Attractive factories, with clean and orderly surroundings and with the interior kept orderly and immaculately clean, are a good advertisement for the cheese industry. Unless proper attention is given to the sanitary condition of the factory, the milk quality improvement program is of little value.

Whether greater emphasis should be given to improvement in the milk or to improvement in the manufacturing and ripening methods is debatable. Certainly high quality milk is basic. But the two are inseparable. In the opinion of one observer the control of the manufacturing operations so as to produce a uniform product from day to day is of most importance to the group of cheese factories which he represents.

A member of an organization which operates a considerable number of cheese factories feels that the future development and expansion of the cheese industry depends entirely on the industry and on the amount of research which the cheese manufacturing organizations and the colleges will do.

There are many problems that should be investigated - too many to enumerate here. While the art of cheesemaking is one of the oldest, the science of cheesemaking is still in its infancy. We need teams of investigators in different research laboratories and pilot plants. We need the fullest cooperation of the chemist, the physicist, the bacteriologist, and the dairy technologist in solving the intricate problems involved in (1) producing satisfactory bacterial and mold cultures; (2) developing practical methods of processing and handling the milk and curd in the cheese factory; and (3) studying the chemical and physical changes that take place during ripening. We need scientific explanations for the causes of the many defects that may occur in cheese quality, and we need the engineer, trained to understand dairy processes, to develop more convenient, labor-saving and sanitary methods of handling milk and curd in the factory.

Cheese is now the most laborious of all dairy products to make. "The cheesemaking process will never be right," stated one authority on cheese manufacture, "until we can take the milk from the weigh stand and keep it out of sight until the finished product appears at the end or close of the cheesemaking operations. The product should be as completely protected as our fluid milk is today."

Technological research, in addition to that involving mechani-
zation of the manufacturing and packaging operations, should have for its purpose: (1) the manufacture of cheese true to type which has a fine flavor, body, and texture; (2) reduction of the ripening time; (3) greater utilization of whey for human consumption; (4) better disposal of cheese factory waste; and (5) adequate mold control on the surface of cheese. Such research will pay big dividends. Quality will improve, costs will be reduced, and sales will increase under such a program. (U.S.D.A. and several states spent a total of 10 million dollars over a period of 30 years on corn crop research. The farmers have benefited from this through obtaining better corn and higher yields resulting in increased annual estimated returns of $750,000,000.00).

The training of young men to become either cheesemaker, milk grader, cheese grader, analyst, or research worker should be emphasized by the agricultural colleges. Such training may require from one to four years or even longer. If all cheesemakers were to receive a one-year college training course which would include elementary courses in bacteriology and sanitation in addition to specialized dairy subjects improvement in cheese manufacture would be remarkable.

State licensing of cheesemakers, who have demonstrated their qualifications to make cheese and who successfully pass a satisfactory oral and written examination, is a successful program in Oregon. Canadian cheese factories employ certified cheesemakers.

I wish to quote a statement here which was made by a noted Canadian authority on cheese. "As new men come into the industry they do not often have sufficient appreciation of the fundamental principles involved in the manufacture of cheese, with the result that they are not able, except by trial and error to appraise correctly the effect of suggested modifications in the making of cheese which might result in a saving of time and labor. It seems, therefore, that more emphasis could well be placed to good advantage on technological research involving manufacture and ripening of cheese, so that when attempts are made to reduce the labor in making cheese by the introduction of new methods or machines there will be less danger of these affecting, adversely, the ultimate quality of the particular type of cheese being made. It is felt by many in this country that the work of making cheese and the time required to ripen cheese properly needs to be reduced, but this should not be done at the expense of those fine distinctive characteristics of high quality cheese."

The next important emphasis should be on research to improve the varieties of cheese in addition to Cheddar. It is believed that sales can be materially increased if several varieties of cheese of a standardized quality were always available in food stores. The cheese must be attractively packaged and preferably rindless. The price must not be excessive for the majority of the consumers. It is not beyond the realm of possibility that several new varieties
could be developed. There appears to be an opportunity also to promote the sale of brick, domestic Swiss and certain soft and semi-soft ripened cheese.

Has the development of the cottage cheese marketing program been neglected in some states? There appears to be an opportunity to materially increase the sale of cottage cheese. This palatable food containing valuable milk nutrients could be consumed in much larger quantity. Cottage cheese is a versatile food. It can be used as a base in the preparation of a number of different salads as it blends well with many vegetables, fruits and nuts. Creamed cottage cheese may be prepared with the addition of olives, pimento, chive, relish, etc. Let us look at the consumption of cottage cheese in California. During the ten-year period 1937-1946 production of cottage cheese (uncreamed) increased from 19 million to 40 million pounds. A total of 57 million pounds of the creamed product was sold in 1946. The consumption per capita in California of uncreamed cottage cheese was 4 1/2 pounds and of creamed cottage cheese 6-1/3 pounds during the year 1946. Comparing the California consumption of uncreamed cottage cheese with the average of that of the United States it is seen that California's consumption was 265 per cent greater than the U. S. average. Surely by manufacturing a high quality product and using good merchandising methods sales of cottage cheese in the states where consumption is low could be greatly increased. The manufacture of cottage cheese would give a good market outlet for milk solids not-fat.

Neat, attractive displays of varieties of cheese will appeal to the public and will stimulate their appetite for cheese. Most anyone who enjoys food at all usually will like to eat cheese. To those who feel they do not like cheese, the likely answer is they haven't tried enough varieties.

Many varieties of cheese are sold as processed cheese. It is likely that consumer acceptance of varieties of processed cheese put up in glass or wrapped in transparent film will continue. Cheese foods and spreads will also be sold in increased amount. Research on these products will continue. A chemist in one organization has stated that it is theoretically possible to prepare processed cheese with probably all of the advantages of natural cheese plus its own special advantages of almost complete sterility and better keeping quality.

When American people buy food they trust that it is wholesome. They leave to the food regulatory officials to throw the necessary safeguards around the production and handling of food as well as the water supply. It is the responsibility of the cheese industry to supply the consumers with a clean, safe product. This can be accomplished by using milk produced under sanitary conditions, properly cooled, and by manufacturing cheese in a sanitary plant. Persons handling milk and curd must be healthy. Pasteurization of milk or
cheese is an added safeguard, as all common pathogenic bacteria, if present, are killed. An aging period of the cheese of not less than 60 days for raw milk cheese may also be used as a safeguard as pathogenic bacteria find conditions in cheese unsuitable for their growth. It is likely that before too long all cheese will be made from pasteurized milk and we will undoubtedly see the introduction of new methods of pasteurizing milk such as pasteurizing in a partial vacuum, the use of electricity, etc. The new Federal Food & Drug Administration's standards of identity for cheeses, processed cheeses, cheese foods, cheese spreads, and related foods, when promulgated, will be an important factor in safeguarding public health. All of the larger cheese manufacturing organizations are, at present, vigorously promoting more sanitary milk production and cooling of milk on the farms. Through their own initiative, with the adoption of pasteurization, the installation of stainless steel equipment, sediment testing, grading of milk, and the adoption of strict sanitary methods in the factories, they have worked for the application of further safeguards of public health.

If future progress of the cheese industry is to be made it will depend to a great extent on research. Further studies on nutritional properties of cheese, cheese foods, and whey products should be sponsored in a large way and the findings from such research should be given to the public.

Packaging of "natural" cheese in consumer-size, sanitary packages should be emphasized. The cheese sold in this manner must be rindless, it must not shrink in weight and it must not become moldy. There are many unsolved problems in connection with the marketing of cheese in this form. As the trend is for all cheese to be sold in packages of various size, research is needed to develop the best methods of packaging. It is essential, if cheese is to be sold in the form of consumer packages, to (1) standardize the quality of cheese placed in the packages; (2) use only superior quality cheese; (3) keep the packaged cheese refrigerated in the retail stores; and (4) sell the old stock first. To please all the customers it will be necessary to sell Cheddar cheese of different degrees of ripeness; namely slightly aged, medium aged, and fully aged. Quality is the real risk in a cheese packaged at the factory. If the quality of the product when the consumer removes the wrapper is not satisfactory or if the cheese is moldy on the surface, the wrapper only serves to identify for the consumer the kind of cheese which he will not want to purchase again. The prediction has been made that after another ten years practically all cheese will be sold in consumer-size packages.

Merchandising methods need further study and improvement. If cheese sales are to be increased proper attention should be given to providing satisfactory refrigerated display cases in all food stores. This is of paramount importance. The quality of natural cheese is severely damaged if the cheese is kept at room temperature
for some time in the stores. Salesmen can render a great service by seeing that cheese is properly refrigerated, protected against contamination and attractively displayed in retail stores.

The cheese industry has a bright future. The trend in consumption will likely be upward. The factors involved in the expansion of cheese sales are:

(1) Continued high consumer income and the desire by the consumers for good food of which cheese is one.

(2) Shortage of meat and meat products. The forecast is for a decrease of $\frac{1}{2}$ billion pounds in meat production in 1948. Less chickens and eggs will be available.

(3) Cheese quality improvement and standardization of quality. More aged cheese having a pronounced flavor should be marketed.

(4) Varieties of cheese other than Cheddar should be offered for sale.

(5) Reduction in cost of production through developing economies in the manufacturing and packaging of cheese and more efficient utilization of whey.

(6) Improved merchandising methods.

(7) Further education of consumers regarding the nutritional value of cheese and in the methods of using cheese to advantage in preparing menus.

(8) Education of homemakers in methods of serving and caring for cheese in the home so that the product will have maximum palatability.

Acknowledgment. To the leaders in the cheese industry in the United States and Canada who so kindly have given their opinion regarding the manufacture and marketing of cheese, the author of this paper extends his sincere thanks.
CONSIDERATIONS IN THE MANUFACTURE
OF ICE CREAM OF EXCELLENT QUALITY

After a journey through the tropics with the thermometer registering about 100°F, the writer arrived at Ames, Iowa, one exceptionally cold winter morning a number of years ago. The temperature was 25 degrees below zero Fahrenheit. The annual Dairy Manufacturers' short course was being held at Iowa State College and the writer was invited to attend the evening meeting. To his great surprise ice cream was served as refreshment at the end of the session. Although it was biting cold outside and the windows were frosted over, the interior of the building was very comfortable. The ice cream was delicious and was enjoyed by all present.

This incident is mentioned here as an illustration to show the fondness of the American people for "America's Favorite Food."

Ice Cream Liked by All

Ice cream is one food that is enjoyed by all people, young and old. It is fit for royalty. Ice cream was a part of the wedding breakfast at Buckingham Palace, London, England, given by the King and Queen of Great Britain, following the marriage of their daughter, Princess Elizabeth to Philip Mountbatten. All of Europe's royalty attended. The breakfast menu consisted of fish, partridge, ice cream and cake.

We eat ice cream because we like:

1. The delicious flavor
2. The sweet taste
3. The attractive color
4. The fine smooth texture and the mellow body
5. The refreshing coolness of the product

Ice cream is a highly nutritious food. There is no waste. It is made from fine materials that are pasteurized, and it is made by means of modern equipment in sanitary plants by skilled persons.

During the year 1946 a total of 709 million gallons (2,832,000,000 quarts) of ice cream was manufactured in the United States. This was 50 per cent more than during 1945 and 190 per cent more than the year 1936, ten years earlier. There was an increase of 460 per cent in 25 years.
Goal One Billion Gallons Per Year

The ice cream industry is planning for a further increase in the amount of ice cream manufactured. The goal is one billion gallons of ice cream per year before 1950 and some manufacturers are optimistic enough to predict a yearly production of two billion gallons a year before another 25 years.

Quality Comes First

The industry program as outlined by the executive secretary of the International Association of Ice Cream Manufacturers, Mr. R. C. Hibben is:

(a) Quality products.
(b) Aggressive, intelligent merchandising
(c) Good public relations
(d) Sensible industry relations
(e) Meeting competition from outside industry
(f) Intelligent handling of detrimental legislation
(g) Taking advantage of new inventions and new economic conditions.

It will be noted that quality is listed first. We are here today to discuss the subject of the essentials for high quality in ice cream. These essentials may be listed as follows:

1. The use of clean, fresh, sweet cream of fine flavor.
2. The use of condensed milk or dry milk that is fresh and that has no undesirable heated or other undesirable flavor.
3. The use of the proper amount of sweetening agent such as sugar or bland syrup.
4. The use of sound and fresh flavored fruits and nuts in an adequate amount.
5. The use of the correct amount of a satisfactory stabilizer.
6. The use of flavoring materials that will result in a delicious flavor of the ice cream.
The ice cream maker has the responsibility of (1) correctly mixing the cream, sugar, milk solids, flavor, etc., in correct proportions, and (2) processing and freezing the mix in such a manner, that the ice cream will possess all the desirable characteristics. The ice cream maker should at all times endeavor to manufacture the highest quality of ice cream.

**Improvements Made.**

Great strides have been made during the past 25 years in the equipment and facilities used and the methods employed in the manufacture and distribution of ice cream. During this time we have seen the disappearance of the brine freezer, ice and salt cabinets and tubs, pans for brick ice cream, and we have seen the introduction of stainless steel equipment, efficient pasteurizers equipped with control instruments, improved homogenizers, cabinet and plate coolers, direct expansion batch and continuous freezers, and automatic refrigeration machinery. The method of quick hardening of ice cream is employed and packaging in single service paper containers is widely used. Ice cream is now being transferred from plant to retail outlets by the use of attractive refrigerated trucks. Ice cream is no longer a product made chiefly during the summer, but as a result of good merchandising methods it is sold in large quantities throughout the year.

Plain ice cream is a dairy product which consists of approximately 86 parts cream with added milk solids; 14 or 15 parts sugar; and one part stabilizer, egg and flavor. The total milk solids average 23 per cent and the food solids per gallon of finished ice cream will range from 1.6 to 1.8 pounds. The weight of the ice cream per gallon will be approximately 4.5 pounds. For fruit ice cream is used from 13 per cent (strawberries) to 25 per cent (peaches) of ripe fine-flavored fruit or fruit juice. Some sugar may be added with the fruit. A small amount of food color is sometimes added to the ice cream.

The ice cream industry used during 1946 the following approximate amounts of major ingredients:

- 734,000,000 pounds total milk solids
- 500,000,000 pounds sugar and syrup
- 30,000,000 pounds stabilizer, egg solids and flavor
- 75,000,000 pounds fruit
- 10,000,000 pounds nuts

**Quality Paramount**

In connection with the periodic checking of the quality of the ice cream, E. L. Walker of Arden Farms Company recommended that,
"every ice cream production department, whether large or small, could very well afford to have one or more individuals to do nothing else but test and taste and check for color, flavor, and texture of every product before and after it is manufactured and before it leaves the plant to go to dealers and consumers. One of the most serious faults in our industry is the careless practice of some plants in allowing products to get by their doors without double checking. And they often find out, after it is too late, that they could very easily have corrected a number of defects in the product and thus have improved its quality materially without extra cost. Remember we are responsible for our products from the grower to consumers. It is well to remember that consumers are now buying more and more in accordance with sight, taste, and purse. The honeymoon of loose spending is about over and from now on a product has got to measure up to the consumer's idea of full and real value or he just won't buy it and the judgment and the ability of consumers to appraise values is becoming keener every day. They are not easily fooled any more."

The writer, previous to the war, for several years, made trips to a large ice cream factory in Oregon to check on the methods of manufacture, inspect the plant for sanitation, check the sanitary condition of the equipment, and make tests on the ice cream for quality. This latter included the scoring of a number of samples of ice cream for flavor, texture and body, melting quality and color, and the analyzing of the samples for composition, including a determination of the numbers of bacteria present. At the time of the visit, one of the salesmen would purchase samples of ice cream, made in other factories, in retail stores. The samples of ice cream were then placed in plain containers and numbered. They were then examined and the quality was compared with that of the ice cream manufactured in the plant being visited. The results from all this work aided the management of the organization in improving the conditions and methods employed in the factory.

Unless a comparison with the quality of the ice cream made in other factories is made, from time to time, it is somewhat difficult to discover in what respect the quality of the ice cream manufactured is weak. Such a comparison of the quality of ice cream samples will generally show that a considerable variation exists. Each manufacturer, as a rule, thinks that his ice cream is the best, and that, of course, should be his goal. He may be surprised, however, that when his ice cream is compared with other samples of ice cream, it may be less satisfactory in one or more of the factors that make up quality than some of the samples. This should urge him to do everything within his means to improve his product.

Commercial ice cream now manufactured shows less variation in quality than it did several years ago. The flavor is much better as a result of using fresher and higher quality milk, cream, and concentrated milk products, superior flavoring materials and less
imitation flavoring products. The texture is much superior. It is smoother as a result of using better freezing and hardening methods. The body is less apt to be soggy, a common complaint a number of years ago. In melting quality we still have some defects such as "does not melt" and "curdy when melted." Although the color of plain vanilla ice cream is generally satisfactory occasionally the ice cream will have an unnatural shade of color or a too-high color. Fruit ice cream is sometimes greatly overcolored.

For the annual college students' ice cream judging contest held during the time of the Pacific International Livestock Exposition at Portland, ten one-gallon samples of commercial ice cream obtained from different plants are used. For the 1947 contest two ice cream manufacturers and an experienced ice cream maker placed the official scores on the samples.

Three samples were not criticized for flavor. The remainder were criticized for either egg, lack of flavoring, coarse, cooked, acidy, unnatural flavoring, high sweetness.

Three samples were given a perfect score for body and texture. The remainder were criticized for being weak, coarse, or icy, soggy.

Six samples had a satisfactory melting quality. The remainder were criticized for either curdy or "does not melt."

Seven samples had a satisfactory color. The remainder were criticized for unnatural or too-high color.

For the manufacture of ice cream of excellent quality are required:

A. A sanitary plant - well lighted and ventilated; clean walls, floors, doors and windows in manufacturing rooms; well arranged hardening room kept at uniform low temperature; a satisfactory water supply.

B. Milk, cream, condensed milk products fresh and low in bacterial content.

C. Fruit, flavors, sweeteners, stabilizer, egg, colors of fine quality.

D. Modern, clean, well kept equipment.

E. Correct mix standardization, mixing, homogenization, and freezing.

F. Efficient hardening.
G. Maintaining fresh stocks of ice cream.

A dependable supply of milk and cream is a primary necessity. At certain times, especially during July, August, and September, a sufficient amount of sweet cream may not be available. It may be necessary to use either stored frozen sweet cream, unsalted butter, or plastic cream.

Fine Quality Milk and Other Milk Products Must be Used.

The milk used should be satisfactory to at least \(5\frac{1}{2}\) hours' methylene blue test. It should be free from extraneous matter and should not have a stale, rancid, salty, or other undesirable flavor.

The cream used for storage purpose should be of the highest quality and should not come into contact with copper equipment. It should contain 40-45 per cent fat. To retain the desirable physical property of the cream either 12 per cent sugar or 15 per cent corn syrup may be added. Pasteurization at 170\(^\circ\) - 180\(^\circ\) F. for 30 minutes is recommended. Sterilized well-timed containers should be used. Place a parchment paper under the lid. Store the cream at a temperature of -10\(^\circ\) to -20\(^\circ\) F. Use the thawed cream quickly, otherwise a tallowy flavor may soon develop. To conserve space high testing plastic cream (75 to 80 per cent fat) can be stored.

Unsalted butter made from fine quality sweet cream may be stored. To improve the whipping property egg yolk may be used in the mix. The melted butter may be first emulsified with skim milk and egg yolk by passing the mixture through a homogenizer.

A recent important development is the preparation of dry butterfat and storing this for future use in ice cream. One method of manufacture which will be protected by patent is as follows:

1. Cream of fine quality is separated at approximately 120\(^\circ\) F. by means of especially constructed centrifugal separator to get a high-test product containing 90 to 95 per cent fat.

2. The product is re-separated so that butter oil containing less than one per cent moisture is obtained.

3. The butter oil is continuously subjected to high temperature pasteurization at 195\(^\circ\) to 200\(^\circ\) F. under partial vacuum, to steam distillation, and to partial cooling in a chamber maintained at nearly complete vacuum in a Vacreator. This treatment effectively removes all traces of moisture and insures keeping quality. Because the product moves through vacuum chambers continuously and is briefly subjected to the high heat
treatment, the total time for vacreation treatment being only 3 seconds, there is no impairment of the flavor of the oil caused by the heat.

4. The moisture-free oil is congealed continuously in a machine constructed like a continuous ice cream freezer to be extruded and placed in containers.

It must be emphasized that it is of utmost importance to use cream of the highest quality in the manufacture of dry butter fat. If made from inferior cream, even though the final product may taste perfectly bland, upon homogenization in skim milk, the undesirable flavor becomes discernible.

Dry butterfat keeps well without refrigeration and because it contains no moisture it is more practical to store than butter, frozen cream, and plastic cream. The fat, if properly packaged, will keep for one year without refrigeration at ordinary warehouse temperature, but if it is to be stored for over one year it is safer to store it at 0°F.

The source of additional milk solids may be one of the following:

1. Spray process nonfat dry milk solids.
2. Unsweetened condensed skim milk.

If equipment for the condensing of milk is available, the factory may profitably utilize locally-produced milk in the preparation of condensed milk. A small condensing pan or a Vacreator may be used. A dependable supply of milk must always be available for any ice cream factory. Condensing the milk to a concentration sufficient so that when added to the mix, this will be exactly of the desired composition, is the most economical method. If purchased from a nearby plant either unsweetened or sweetened 3:1 condensed skim milk may be purchased.

Dry milk solids should be manufactured from fine quality milk. The solubility should be high. No brown particles or extraneous matter must be present. Frequent purchases of freshly-made powder should be used. Never use stale-flavored dry milk for ice cream mix. If in doubt reconstitute the powder and taste the milk. Always store the powder in a dry storage room at a temperature of 50°F or below.

If egg yolk is used it should be of extra grade. Dry egg yolk will become stale if stored too long at a high temperature. It should be stored in a refrigerator.
Correct compounding of the mix ingredients as well as correct homogenization, pasteurization, and cooling of the mix are necessary if ice cream of fine flavor and of good body and texture, is to be obtained.

Correct Processing of the Mix Important

With the batch method of pasteurization, homogenization usually follows pasteurization. With the high temperature quick time continuous method of pasteurization, homogenization may precede pasteurization.

Efficient homogenization consists of breaking up the fat globules so they are uniformly small in size, about one micron in diameter if possible — never over two microns in diameter. With the modern homogenizer, subsequent fat clumping is prevented. Homogenization of a mix of standard composition at a temperature of 160° to 165° F., and at a pressure of 3000 to 3500 pounds, first stage, will be found very satisfactory.

A high homogenizing pressure is desirable for thorough subdivision of the fat globules resulting in a superior whipping property of the mix. An excessive pressure may cause a too high viscosity. A desirable per cent overrun is obtained quicker and the ice cream will have a superior body and texture than if the fat globules are not sufficiently subdivided. It is important that mix proteins be adsorbed in adequate amount on the fat globules during and immediately following homogenization. Otherwise the mix will whip poorly. In order to accomplish this it is necessary, as suggested by Leighton (Vol. 31, No. 2., The Ice Cream Review) to consider such factors as size and type of homogenizing valves, condition of valves, and the amount of mix which passes through the homogenizer. Measuring the degree of fat dispersion is, therefore, not sufficient for determining the efficiency of homogenization. Leighton recommended preparing whipping curves when a batch freezer is used. If the overrun is plotted against the temperature existing in the freezer at intervals as the ice cream warms up, after the refrigeration is shut off, a reproducible straight line will result, which can be used as a measure of the whipping capacity of the particular mix. With mixes of identical composition the one which incorporates the most air at a given temperature may be considered to possess the best whipping quality, he stated.

According to Wakeman and Gillespie (Milk Plant Monthly, Vol. 35, No. 2) the amount of butter that appears on the freezer dasher after a period of freezing is the best index for judging the efficiency of mix homogenization. Homogenizing pressures which are either too high or too low may cause excessive buttering on the freezer dasher, even though microscopic examination would show fair homogenization.
If the ice cream mix is held at a high temperature, more than one-half hour after pasteurization, the mix may partially destabilize, causing buttering out on the freezer.

**Stabilizers to Use**

Recently Tracy (The Ice Cream Review, Vol. 31, No. 2) gave a summary with reference to the use of stabilizers and whipping agents in ice cream mix. The following are excerpts:

"Gelatin can be added to the cold mix or blended with some of the other dry ingredients. The amount of gelatin needed varies from 0.25 to 0.5 depending upon the strength of the gelatin, its type, the percentage of total solids in the mix, the rate at which the mix is cooled, the type of freezer used, and the drawing temperature. High pasteurizing temperatures affect the gel action only slightly. Mixes containing gelatin develop viscosity upon aging and have their minimum viscosity during processing. This may or may not be an advantage. It is a disadvantage when mixes are prepared for resale to small ice cream manufacturers who are confused by mixes varying in viscosity. The light viscosity of the gelatin mixes at the cooler makes it possible to use higher refrigeration temperatures at the cooler and facilitate the pumping and cooling processes. It is important when cooling a gelatin mix to lower the temperature rapidly to 40° F. If for some reason the mix is cooled to only 60° to 70° F. at the cooler and then permitted to continue cooling to 40° F. at a slow rate during storage, the gelatin will produce a greater viscosity than if the temperature had been lowered rapidly to 40° F. at the cooler. A slowly cooled mix will whip less rapidly and will have a more resistant body after being frozen. Gelatin does not destabilize the mix protein. Ice cream properly stabilized with gelatin will have a desirable type body and texture with good melt-down characteristics. Gelatin is less favorable to shrinkage in ice cream than some stabilizers.

"A gum called Carob bean, or locust bean, imported from France and Belgium, has been used in ice cream, sherbets, and ices. The product has good mix stabilizing properties, even when used at low levels (0.12 per cent), but unfortunately it reacts with casein of the mix causing wheying off. For this reason when used in ice cream it is usually combined with some other gum or with gelatin.

"Pectin is a colloidal carbohydrate obtained from apples and citrus fruit wastes. Pectin is usually sold to the ice cream trade as a blend with other types of gum stabilizers and has proven most useful in the manufacture of sherbets and ices and in the preparation of syrup for ripple ice cream.

" 'Dariloid' is a colloidal carbohydrate found in kelp that grows on the Pacific Coast of the United States. From 0.2 to 0.3 per
cent is usually sufficient for stabilizing the finished ice cream. The product is usually mixed with a portion of the sugar and added to the mix at 160° F. It may be added in a water solution at a lower temperature. 'Dariloid' produces an immediate viscosity effect in the mix which changes but little during aging. Mixes containing this stabilizer have good whipping qualities and the ice cream has desirable melt-down characteristics. Mixes to which certain sodium salts, and neutralizers have been added may develop excessive viscosity when stabilized with sodium alginate. Raising the pasteurizing temperature beyond 160° F. and extending the holding period at 160° F. increase the mix viscosity. Slow cooling of the mixes stabilized with sodium alginate also causes an increase in mix viscosity.

"Irish moss is a derivative of a marine plant, carrageen, grown off the coast of Ireland, France, and Massachusetts. When used alone only about 0.12 per cent is necessary to stabilize a mix. However, in order to obtain better results in the ice cream other gums are usually added together with corn sugar which acts as a carrier for the gume. There is a commercial product on the market containing essentially Irish moss called 'Krageleen.' About 0.2 per cent is needed to stabilize the mix.

"Quince seed contains a water soluble gum with distinct colloidal properties. Only about one-tenth as much is needed to stabilize the mix as in the case of 225 Bloom gelatin.

"One of the newer gums to be used in ice cream is Oat gum. It is a derivative of the oat grain. It produces an immediate viscosity in the mix and has certain anti-oxidant properties. Approximately 0.5 per cent is necessary for stabilizing so that it is sometimes combined with other gums or gelatin.

"Sodium-carboxy-methyl-cellulose has colloidal properties. When used alone about 0.18 per cent will stabilize a mix containing 37 per cent total solids. It is compatible with other types of stabilizers and is often blended with gum or gelatin when used in ice cream. An immediate viscosity is formed in the mix by this stabilizer. The mix whips well and the ice cream has good body and melt-down characteristics. There is no deleterious effect upon flavor.

"The use of mono- or di-acid glycerides of either plant or animal origin for emulsifying ice cream mixes has been patented by Swift & Company. 'Vestirine,' a commercial product on the market, containing a combination of the glyceride and gelatin, has been successfully used in ice cream. The whipping agents, which have strong emulsifying properties, result in faster whipping, smaller air cells, a drier ice cream, and a smoother texture. The ice cream seems to be creamier giving the impression of greater richness or higher fat content. Because of the effect of the emulsifying agent in producing smaller air cells and smoother texture, the ice cream is more likely to shrink. For this reason consideration should be given to all other
factors that favor shrinkage and avoid having too many such factors present in the same mix.,"

Specifications for an ideal stabilizer, based on a discussion with Dr. P. H. Tracy were recently (January 1948) made by one manufacturer of ice cream stabilizer. He reported that they are:

"1. Price - the stabilizer should be economical to use.
2. The stabilizer should be easy to add to the mix.
3. The stabilizer should be completely dispersible.
4. Aging of the mix should not be necessary, in order to obtain full benefit from the stabilizer.
5. The stabilizer should not produce an extraordinary heavy immediate viscosity, which would be troublesome in cooling and pumping.
6. The stabilizer should be stable to pH changes in mix.
7. The stabilizer should not be affected by the use of neutralizer in the mix.
8. The stabilizer should produce a desirable texture.
   (a) A chewy texture
   (b) Small ice crystals
   (c) The texture should hold up over a long period of time and withstand heat shock.
9. The stabilizer should have desirable whipping properties. However, he expressed the opinion that this was not too important, inasmuch, as the whipping could be controlled rather easily by the use of emulsifying agents.
10. The stabilizer should not accelerate shrinkage. The ideal case, of course, would be if it prevented shrinkage.
11. A stabilizer that can be used in both sherbets and ice cream would be highly desirable.
12. The quantity used should not be so great as to become an actual factor, nor should it be so small as to introduce difficulty in using.
13. The stabilizer should be uniform."

Freezing and Hardening, Other Important Steps

It has been reported that in some of the larger cities in the United States 90 per cent of the ice cream is frozen in continuous freezers. Among the many advantages of the continuous freezer may be mentioned: (1) It is possible to obtain a smoother and more uniform textured ice cream than with a batch freezer; (2) The control of overrun is better; and (3) it is possible to fill pint and quart containers directly from the freezer.

The freezer, whether of the batch or continuous type, should be maintained in top mechanical working condition. The scraper blades must be sharp and straight. The supply of refrigerant must be ample
so as to permit operating the freezer to its full capacity. With a modern freezer a large percentage of the water in the mix can be frozen during the freezing process, and air can be incorporated to obtain maximum overrun when the partly frozen mix is quite stiff. With the batch freezer the temperature is generally about 24°F when the refrigerant is shut off. With the continuous freezer the temperature of the ice cream as it leaves the machine is about 22°F, assuming that a mix of normal composition is frozen.

The amount of water frozen in ice cream at various temperatures is shown in the accompanying table.

The temperature of the hardening room should be uniform during the night and day, with the temperature maintained at -15°F and the air in the room circulated. The temperature of ice cream in five gallon cans can be reduced to that of the hardening room in about 12 to 14 hours. Quick hardening and uniform temperature in the hardening room favor the formation of fine ice crystals and are thus important in producing ice cream that has a fine texture. Hardening tunnels maintained at a temperature of -30°F to -40°F, and the air circulated, are also used for packaged goods. The ice cream will harden in about 1 to 2 hours depending upon the size of the package.
**DISTRIBUTION OF WATER, ICE AND SUGARS IN ICE CREAM AT VARIOUS TEMPERATURES**

Composition: 12% Fat, 10% Serum Solids, 14% Sugar

<table>
<thead>
<tr>
<th>Condition of Ice Cream</th>
<th>Temperature</th>
<th>Water</th>
<th>Ice</th>
<th>Percentage of water as ice</th>
<th>Sugar in Syrup</th>
<th>Total Sugar</th>
<th>Total Weight of Unfrozen Syrup</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At freezing point</td>
<td>27.9</td>
<td>64</td>
<td>0</td>
<td>0.0</td>
<td>16.8</td>
<td>6.5</td>
<td>23.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23.3</td>
<td></td>
<td>83.4</td>
</tr>
<tr>
<td>Start freezing</td>
<td>27.7</td>
<td>60</td>
<td>4</td>
<td>6.2</td>
<td>17.6</td>
<td>6.9</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24.5</td>
<td></td>
<td>79.4</td>
</tr>
<tr>
<td>Drawn soft</td>
<td>26.8</td>
<td>50</td>
<td>15</td>
<td>21.9</td>
<td>21.9</td>
<td>20.2</td>
<td>28.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28.0</td>
<td></td>
<td>69.4</td>
</tr>
<tr>
<td>Drawn firm</td>
<td>25.5</td>
<td>40</td>
<td>24</td>
<td>37.5</td>
<td>37.5</td>
<td>23.5</td>
<td>32.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>32.7</td>
<td></td>
<td>59.4</td>
</tr>
<tr>
<td>Drawn hard</td>
<td>24.4</td>
<td>35</td>
<td>29</td>
<td>45.3</td>
<td>45.3</td>
<td>25.7</td>
<td>35.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35.7</td>
<td></td>
<td>54.4</td>
</tr>
<tr>
<td>Drawn very hard</td>
<td>22.9</td>
<td>30</td>
<td>34</td>
<td>53.1</td>
<td>53.1</td>
<td>28.3</td>
<td>39.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>39.3</td>
<td></td>
<td>49.4</td>
</tr>
<tr>
<td>Semi-hardened</td>
<td>17.5</td>
<td>20</td>
<td>44</td>
<td>68.7</td>
<td>68.7</td>
<td>35.5</td>
<td>49.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>49.3</td>
<td></td>
<td>39.4</td>
</tr>
<tr>
<td>Serving(trifle soft)</td>
<td>11.8</td>
<td>15</td>
<td>49</td>
<td>76.5</td>
<td>76.5</td>
<td>40.6</td>
<td>56.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>56.4</td>
<td></td>
<td>34.4</td>
</tr>
<tr>
<td>Hard</td>
<td>1.0</td>
<td>10</td>
<td>54</td>
<td>84.3</td>
<td>84.3</td>
<td>47.5</td>
<td>66.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>66.0</td>
<td></td>
<td>29.4</td>
</tr>
</tbody>
</table>

The above data by A. C. Dahlberg in "Ice Cream Trade Journal" Vol. 28, No. 1, p. 31, 1932.
A ROUND-UP OF DEVELOPMENTS IN DAIRY MANUFACTURING AND DAIRY TECHNOLOGY SINCE WORLD WAR II

The amount of milk produced in the United States was boosted from a prewar production of 112 billion pounds during 1940 to over 120 billion during the war years. For 1947 it was still above this figure with 122 billion pounds being produced. The milk came from about 25 million cows.

Of this amount of milk about 1/2 was consumed in the fluid form and the other half was used in the manufacture of dairy products. The percentage distribution of the utilization of milk for various purposes during 1947 in accordance with the United States Department of Agriculture (1) was:

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>For fluid milk and cream</td>
<td>46.89</td>
</tr>
<tr>
<td>For butter</td>
<td>26.78</td>
</tr>
<tr>
<td>For cheese</td>
<td>9.05</td>
</tr>
<tr>
<td>For canned milk</td>
<td>6.27</td>
</tr>
<tr>
<td>For dry milk</td>
<td>1.45</td>
</tr>
<tr>
<td>For ice cream</td>
<td>6.10</td>
</tr>
<tr>
<td>For other uses</td>
<td>2.66</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
</tr>
</tbody>
</table>

In addition to the products made from whole milk and cream large quantities of nonfat milk solids, dry and condensed whey and cottage cheese were manufactured. The production of nonfat dry milk solids set a new record of 676 million pounds for 1947.

Many advances in the field of dairy manufacturing and dairy technology have been made during the war years and during the three years since V-E day. It is difficult to single out any one piece of research that has been the most important. The developments have come about through the combined effort of the chemist, the physicist, the engineer, the bacteriologist, the nutritionist, and the dairy technologist. With the stressing by nutritionists of the importance of an adequate amount of dairy foods in the American diet, our general health has not suffered as a result of the war conditions; this is in contrast to that of the people in certain foreign countries where dairy products have been scarce for a number of years. The American people consider dairy products among the most valuable food products.

Of the products sold from the farms milk and cream brought an income in 1946 of 3-3/4 billion dollars. This was 15 per cent of the total farm income from the sale of farm products.
The following are some of the developments that have taken place in recent years. No attempt is made to list them in order of their importance.

Developments in the Market Milk Field

One of the important conservation measures introduced during the war was the every other day delivery of milk to homes. Costs were reduced. This method of milk delivery is generally used throughout the country today. A study was made recently to determine whether this method of handling city milk supplies would adversely affect the wholesomeness or the flavor of the product. The results from this study showed that the keeping quality of milk was good enough at all seasons of the year to permit every second day delivery without impairment of milk quality. It is necessary, it was pointed out, that storage of pasteurized milk in homes should not be above 50°F, to safeguard the healthfulness of milk. (2)

The war and postwar conditions have caused a marked increase in the demand for all dairy products. On account of shifts in population caused by war activities shortages of milk and dairy products developed in many areas. As a result milk and cream had to be transported sometimes long distances to these milk deficient areas. The situation still exists. This has brought up the question of whether there should be a single minimum standard for milk quality regardless of the utilization of the milk. The subject has been discussed by the leaders in the industry. Recently one authority speaking before a state-wide conference was of the opinion that a single minimum standard of quality for milk would be a blessing to the dairy industry and to mankind in general as all the milk solids thus could be used for human consumption rather than converting some of them to cheaper animal feeds as at present. He said that in many states there are established minimum quality standards for milk, but due to the inadequacy of personnel, the regulations cannot be enforced at the origin of production. The burden of enforcement cannot be borne by regulatory officials alone; it must rest in large part with the milk buyer, he pointed out. The legal maxim "Let the buyer beware" may soon apply to milk buyers as to persons in other industries, he warned. The time is at hand when all milk solids, either for bottle or for manufacturing purposes should meet certain minimum quality standards. (3)

A method of collecting milk from farms in tanks instead of in cans has been introduced. The advantages claimed for this method are: (1) a better quality of milk as the milk is at a lower temperature, (2) protection of the milk from dust contamination, (3) saving of labor, and (4) lower cost of transportation. During a symposium on the subject held in August 1947 it was reported that the routes now operating collect from 100 to 800 gallons of milk at each dairy with an average of 300 gallons. The night and morning milkings are cooled at the dairy to 40°F, or below as soon as it is produced.
It is stored in a covered insulated stainless steel tank and held at the dairy until the tank truck arrives. It is then agitated to give a uniform mixture, measured by a graduated stainless steel ruler, sampled for daily tests at the plant and then pumped into the truck tank. Some of the farm storage tanks are equipped with refrigeration coils and agitators. A sanitary stainless steel centrifugal pump is installed at each dairy and the milk is pumped through stainless steel piping and a white rubber tube connection to the truck tank. The rubber tube is left connected with the man-hole cover of the tank between stops and is coiled under the dust cap of the man-hole cover to protect it from dust contamination.

Improvement in glass milk bottle design to provide a lighter, more convenient container has been effected. Many milk plants have during the postwar period adopted these bottles. One type is a "squat" round bottle, the quart size weighing 17-3/4 ounces, having a diameter of 3-7/8 inches; the other is a square bottle weighing also 17-3/4 ounces, and having a diameter of 3-5/16 inches. Both bottles utilize a cap of a diameter of 1-5/16 inch. The round bottle requires a bottom shelf refrigerator area of 15.015 square inches and the square bottle requires 10.972 square inches. The old style round bottle was taller, wider, and heavier. For the square bottle is claimed that it saves refrigerator space, it is easier to handle, consumers prefer it, and more bottles per delivery truck can be carried. A manufacturer reports that between 40 and 50 per cent of glass bottles now being purchased are of the square type.

There has been a tremendous increase in the use of single-service paraffined paper containers since World War II. The increase has been fourfold and the yearly manufacture is now about four or five billion containers per year. The use of paper containers for this purpose is rapidly increasing. A quart paper container fabricated by one manufacturer has a bottom area of 7.91 square inches and weighs only 1.62 ounces. A number of advantages are claimed for the use of single service paper containers for milk: seventeen for the milk plant, nine for the food store, and eight for the consumer. Among these advantages are: lighter and easier to carry; no empties to wash and return; refrigerator space is utilized advantageously, containers stack well, no deposits on container, milk pours easily, the milk is protected against light. The sanitary and practical aspects of paper milk containers were studied several years ago. The results of this investigation showed that paper milk containers were sanitary, as well as practical, for fluid milk distribution.

A more economical method of homogenizing milk was put into commercial use in 1945. The dairy plant in which the method was developed had experienced difficulty in common with many others in synchronizing the fixed capacity of an homogenizer into an otherwise flexible capacity production line for continuous pasteurization and bottle filling. The problem was solved by inserting a separator in place of the milk clarifier so that only that part of the product
leaving the cream outlet of the separator would pass through the homogenizer, this part being reunited with the portion of the milk from the skimmilk outlet of the separator just prior to passage through the final heating section of the high-temperature short-time pasteurizer. The cream control valve was removed from the separator to allow the homogenizer to draw its full capacity (4,300 pounds per hour) from the separator in order to avoid air incorporation. The fat content of the "Cream" going to the homogenizer ranged from 9 to 12 per cent and that of the skimmilk ranged from 0.01 to 0.02 per cent. An homogenizing pressure of 3000 pounds per square inch was used for the highest efficiency. The complete unit was operated under this system at a capacity as high as 16,000 pounds per hour. The new method which was approved by the health department had the advantages of decreased cost of operation and resulted in increased plant efficiency by reducing the operation of the plant on homogenized milk to about one-third. The homogenized milk was demonstrated to be a satisfactory product as judged by top and bottom fat test differentials, curd tension, microscopic appearance, and sedimentation due to leucocytes. (7) This method was studied by a state experiment station. The conclusion was that a highly satisfactory homogenized milk can be produced when the cream portion, containing 10 to 12 per cent fat, is homogenized and then combined with the skimmilk, followed by pasteurization. (8)

A new type heat exchanger known as a "Mallorizer" was offered to the dairy industry a short time ago. The exchanger is equipped with a small diameter internal tube through which the milk product to be treated flows at a relatively high velocity and turbulence. It is reported that the over-all heat transfer with the heater is in the order to 1200 B.T.U. per square foot, per hour, per degree F. log mean temperature difference. It was also reported that it was possible to produce from the Mallorizer sterile milk or cream, place it in a container, where it would keep without refrigeration for ten days or two weeks minimum, with no greater change in flavor than that occurring in the change due to pasteurizing good raw milk. It was reported that Mallorization, because of its ability to sterilize the product completely, would protect both the public and the product. (9)

The use of ultraviolet rays for destroying bacteria in milk has been reported. A method for which a patent has been applied consists of exposing a 1/64 inch thick film of milk to the rays produced by a germicidal lamp. The milk flows over a series of slowly revolving cylinders arranged in pairs one above the other. The parts of the equipment with which milk comes in contact are of stainless steel. The lamps are attached to sliding racks that will slide between each bank of cylinders, and slide out for cleaning. In tests made it was found that the flavor of the milk was excellent. The equipment is suitable for farm use as well as for milk plant use. (10) Another method has been developed by German scientists. The milk in each bank of quartz tubes is irradiated by 12 mercury vapor lamps. Effective penetration of the rays is restricted to about 1 mm. The optimum wave
length for bactericidal treatment was given as 2537 Ångström units. (11)

A method has been developed and apparatus designed to preserve the vitamin C content and retard the development of certain off-flavors in milk by deaerating the milk prior to bottling under air-free conditions. The milk is deaerated by spraying it at a temperature of 105° to 115° F. into a vacuum chamber where an amount of water is evaporated equal to about 0.5 to 2 per cent of the weight of the milk. The temperature is reduced 70° to 15° F. The deaerated milk is removed continuously from the bottom of the chamber at approximately the rate at which it enters and is then cooled and packaged under sub-atmospheric pressure. (12)

With the wider adoption of automatic, continuous processing of milk there is a need for control devices, such as floatless liquid level controls. There are two types of these controls now on the market. One is based on the use of an electronic tube in conjunction with a relay; this is very sensitive. Another is based on an induction type relay. The controls prevent waste, save labor, and increase the efficiency of the milk plant. (13)

The flow diversion valve which is an integral part of a high temperature short-time pasteurizer and is required on the 160°F. - 15 seconds continuous pasteurizers has been simplified and improved. All parts of the new valve that come in contact with milk are 18-8 stainless steel; the valve is made more foolproof in its operation, due to improvement in design of the solenoid valve and interlocking micro-switch; there is no possibility of obtaining forward flow of sub-lethal temperature of milk, if air or power fails, milk is automatically diverted for re-heating; the micro-switch, solenoid valve, and diaphragm motor are completely enclosed. (14)

A new control system for high temperature short time pasteurizers was announced in the leading dairy magazines during May this year. Heretofore, the instruments used to control a short-time pasteurizer consisted of separate units. These now have been combined in one unit along with a number of major refinements designed to provide the user with a simpler and more reliable controller system. The improved controller combines safety thermal limit recorder, water temperature indicating control, and cold milk record. The frequency pen in the safety thermal limit controller can now always be depended upon to give a written record since the pen is moved more slowly by a small electric motor. Also the speed of response of the thermal element in this instrument has been decreased to 2-1/2 seconds, which is twice as fast as allowed by the present U.S.P.H.S. Code. (15)

Improved thermometers to use in vats, milk lines, storage tanks, etc. are now available. They are constructed with 3A Sanitary 18-8 fittings. They are easily read and the Pyrex outer housing is non-fogging. The thermometers are hermetically sealed. (16)
The use of tinned copper for lining milk and cream heating vats, and tinned copper heating and cooling coils in vats, is steadily being discontinued in favor of stainless steel surfaces. With these new types of vats, water at a controlled temperature is sprayed on the side of the lining in a fast continuous stream, thereby heating the milk or cream inside the vat. Insanitary stuffing boxes are dispensed with and the vats are equipped with stainless steel agitators for adequate stirring of the milk of cream during heating. (17)

Further improvement in the Babcock method of testing milk and cream for butterfat content was effected when a new centrifuge was developed. The interior of the centrifuge is automatically maintained at the correct temperature. The machine is equipped with an air circulating duct, an adequate size heating element, and provision for proper speed adjustment and measurement. (18)

Frozen milk was used to some extent during World War II. The quality of the product was variable. Experiments on the manufacture and storage of frozen milk have been in progress during and subsequent to the war. The present knowledge on the subject was recently summarized. (19) Of first importance is the use of fine quality milk. Heat the milk to 170° - 180° F. and condense it to one-third the volume. Homogenize it at 3000 pounds per square inch, cool to 40° F. and place it in containers. Quick freeze the milk in a freezing tunnel and store at -15° F. or lower. Prevent a fluctuation in temperature. When reconstituting place the block of frozen milk in the desired amount of water at a temperature of about 170° - 180° F., and without agitation, allow it to melt. It is predicted that frozen milk has a promising future, but further research is necessary to perfect the procedures to be used.

Sterilized caramel milk was developed in response to a demand by the army for a beverage that could be used hot or cold as a quick source of energy on invasion beachheads when appetites were sluggish. In the experiments to develop the product the caramel base was prepared from a mixture of cream, milk, corn syrup, sucrose and salt. The mixture, totalling 106.3 pounds was heated with stirring to 160°F., and homogenized at a pressure of 2500 pounds per square inch. It was then cooked in a candy kettle with a double action stirrer to 238° F., cooled slightly, and diluted with 8-1/4 pounds water and vanilla flavor. The yield was 84 pounds with a moisture content of 20 per cent. The caramel milk was prepared by adding 14 pounds of the base to 86 pounds milk containing 4.07 per cent fat and 9.18 per cent solids-not-fat. The product would contain 5 per cent fat and 22 per cent total solids. The milk could then be canned and heat sterilized similarly to evaporated milk. (20)
Important Developments in Butter Manufacture

The orthodox method of churning cream and salting and working butter is on the way out and the continuous method of manufacturing butter will be introduced. At this writing the continuous method is in the pilot stage in the United States but within a short time several "experimental" commercial installations will be in operation. The American methods developed by the Creamery Package Manufacturing Company and the Cherry-Burrell Corporation as well as the Australian "New Way" method, the German "Fritz" and "Alfa" methods, the Swedish "Alfa-Laval" method, and the Swiss "Senn" method have already been fully described in former issues of Food Industries. (21) (22) (23) The Butter Plant of Tomorrow promises (1) complete sanitation by eliminating manual handling of butter and exposure to air, (2) less moisture loss during printing and from cut prints, (3) improved keeping quality of the product, (4) easier composition control, (5) less floor space required, (6) fewer man hours per thousand pounds of butter, and (7) lower cost of manufacture.

The All-Metal cast aluminum alloy churn which was developed several years before the war has been improved considerably during the last three years. As this churn meets modern ideas of sanitation the mention of the improvements is justified. The castings which make up the churn barrel are now welded, thus making the churn a one-piece unit with a smooth interior. The churn drive is located in a waterproof compartment and is of the noiseless, roller-chain drive type. By means of a variable speed control the speed of the standard size churn barrel may be varied from 23 r.p.m. to 36 r.p.m. The new style churn is equipped with an ingenious safety switch lock. The key from this switch lock must be inserted in the churn door before this can be opened. Thus it is impossible to start the churn with the door open. The advantage of this is clearly seen. (24)

The use of carotene, obtained from plants, as a coloring agent for butter has been studied during the postwar years. (25) As carotene is the precursor of vitamin A nutritionists favor the use of the product. Studies are now underway to determine the most suitable carrier for the carotene. It must be bland in flavor and must have no unfavorable effect on the flavor of butter when this is held in storage. Whether the color of butter is being enriched with carotene or with some other approved coloring agent it is desirable for the butter-makers to make butter which has a uniform color.

A simple method for standardizing the color of butter has recently been devised. (26) Ordinary creamery butterfat testing equipment is used when making a test on cream to determine the color of the fat of the cream to be churned. A simple procedure is followed. The principle of the test is to warm the cream to 30° C. (86° F.) in a Babcock 18 gram test bottle and shake with a few glass beads to about 40° C, and to extract the fat with petroleum ether, bringing the
solvent containing the fat into the neck of the bottle and adjusting to a known volume. Then by the use of a photometer or color standards it is possible to calculate the amount of carotene or other color to add to the cream to secure the shade desired in the final butter. Some commercial carotene coloring concentrates available for use as color have been found to contain from 2000 to 5000 mcg. of carotene per ml.

Recent Developments in the Cheese Field

The domestic consumption of cheese has increased considerably since World War II. It reached an all-time high of 6.9 pounds per capita in 1946, excluding cottage, or almost 1,000,000,000 pounds. In addition about one-fourth billion pounds of cottage cheese were consumed. Consumption of cheese was estimated to be still higher in 1947. Reasons for the increased consumption of cheese were: the better buying power of the American people during recent years; shortage of meats; the availability of more U. S. made varieties of cheese; more cheese sold in convenient size packages; improved merchandising methods, including the introduction of attractive refrigerated display cases. Results from technological research have also been a factor. It has been emphasized that cheese can be used in many ways. It can be eaten with a number of other foods such as with crackers, bread, fruit, vegetables, macaroni, pie and soup, and it has many uses in cookery. Well-ripened cheese when served as a pre-dinner appetizer is greatly enjoyed by connoisseurs. Merchandising natural cheese by cutting off wedges from a wheel of cheese at the time of sale is about a thing of the past. The modern method is to sell either pre-weighed portions of cheese wrapped in transparent film, or 4-ounce to 5-pound portions which have been packed in glass, tin cans, or transparent film in the cheese factory or central warehouse. The sale of cheese in individual packages has been a major factor in increasing sales and it is likely that cheese sales will be materially stimulated in the future by further improvement in packaging. The purchaser likes the availability, visibility, and economy of rindless cheese in transparent film. Pasteurization of milk is gradually being adopted by the industry as a public health measure to increase the safety of cheese as a food and to enable the cheesemaker to manufacture cheese of more uniform quality. All milk used for cottage and cream cheese is pasteurized and a large percentage of the milk used for Cheddar cheese is now being pasteurized. Research is under way to determine if it will be possible to make Swiss, Limburger, blue-mold, and other varieties of cheese from pasteurized milk. One large organization has reported that it is successfully manufacturing Camembert, Limburger, and other varieties from pasteurized milk. (27)

In the manufacture of cheese about one-half of the milk solids remain in the whey. The total solids content of whey ranges from 6 to
7 per cent. These solids consist of albumen, lactose, fat and minerals. Of the solids, 60 million pounds protein, 92 million pounds lactose, 3 million pounds fat, and 14 million pounds minerals, a total of 169 million pounds were used for human food in 1944. These were in the form of dry whey solids, sweetened and plain condensed whey. For animal feed were used 17-1/2 million pounds protein, 95.4 million pounds lactose, 0.7 million pounds fat, and 12.7 million pounds minerals, a total of 126.3 million pounds. But, of all the liquid whey available 6 billion pounds were returned to the producers or lost. This whey contained 48 million pounds protein, 270 million pounds lactose, 3 million pounds fat, and 36 million pounds minerals, a total of 357 million pounds. (28) With the further expansion of the cheese industry since 1944 still larger quantities of whey solids are available. Condensed whey and dry whey may be used for a variety of food products such as cheese spreads, bakery products, infant foods, soups, and candy. They may also be used for a number of industrial and pharmaceutical products such as pills, penicillin, vinegar, plastics, riboflavin concentrate, protein hydrolyzate, etc. Cheese whey may be used for the production of ethyl alcohol, using a yeast Torula oremoris for fermenting the milk sugar. The method was recently discussed. (29) A yield of alcohol averaging 90.73 in the laboratory and as low as 84 per cent under pilot plant operation was reported.

A new type of cheese vat has been developed. The temperature of the milk and of the curd and whey is regulated by water sprayed at a controlled temperature against the stainless steel inner lining. This type of heating is much superior to the use of either direct steam or hot water in the jacket. There will be no hot spots causing uneven firming of the curd. The heated water is forced by a pump through headers located at the top between the inner lining and outer jacket. The vat can be used for both cottage cheese and Cheddar cheese. (30)

A new short method of manufacturing cottage cheese from non-fat dry milk solids was announced a few months ago. It calls for the use of 20 pounds of solids to each 80 pounds water, to give a product of 20 per cent concentration, or about 2-1/2 times the concentration of ordinary fluid skim milk. To this reconstituted milk is added 12 per cent starter and 12 cc. of a coagulator. The time for "setting" until cutting the coagulum into cubes with wire knives is about three hours. The balance of the process is in accordance with the established procedures. (31) A new dry milk product known as Lacal which contains less of the soluble solids of milk is reported to be of particular value for the manufacture of cottage cheese.

The war caused a scarcity of foreign-made Parmesan cheese, which is in considerable demand as a grating cheese to be used with soup, spaghetti, and other foods. A new method has been developed for making grating cheese that has a high piquant flavor. A satisfactory quality cheese can be obtained when the cream is homogenized before it is added to the raw skim milk, thus promoting the development
of fatty acid that confers a characteristic flavor during a shorter ripening period than was formerly used. (32)

An ingenious method of using electricity for heating water to use for various purposes in a cheese factory in Switzerland has been in use since 1945. The patented system is known as the "Magro." The temperature of water in two boilers with a capacity of 900 gallons is automatically maintained at 244° to 248° F. This water is used for heating milk, whey, curd, and is used for heating the curing cellar and for cleaning the equipment. The installation cost was $6,000.00. With electricity costing 0.61 cent per kwh, the energy cost per ton of milk ranged during April to June, 1946 from $0.52 to $0.64. This was less than if wood had been used and was much more satisfactory. (33)

Reports of developments in the dairy manufacturing field in Canada are printed regularly in Canadian and American Journals and magazines. A new method for determining the "setting" time in Cheddar cheese making was announced a short time ago. In brief the test depends upon the reduction of resazurin dye in a sample of milk to its pink end point. When the milk is incubated at 86° F. for five minutes and the color changes to pink, the milk is ready for the addition of rennet. (34) A rapid method for determining extraneous matter in Cheddar cheese was published several months ago. As a solvent for the cheese is used a ten per cent solution of sodium citrate. (35)

Developments in Dry Whole Milk Manufacture

A new type of spray milk drier in which the milk is dried in an inert gas such as nitrogen or carbon dioxide has recently been developed and proven satisfactory for laboratory purposes. The exhaust gas from the drier is dehumidified and is re-used. This is accomplished by cooling with not more than 20 gallons of 50° F. water per pound of water removed. The inventor of the drier believes that this method of drying would be commercially satisfactory. (36)

Over 500 million pounds dry whole milk were manufactured during the last three war years. Research was in progress at the close of the war in different research laboratories on methods of improving the storage property and reconstitutability of dry whole milk. Some of the research has been completed, other is still in progress. It was stated recently that so far as dry whole milk is concerned we advanced further industrially in four years than we had in the previous 10 to 15 years because the industry accepted the results from basic research and put this into practice. (37) Perhaps the product still needs to be improved but further work will show how the flavor of the product can be improved, how the fresh flavor can be retained during storage, and how the product can be quickly and easily reconstituted.
Dry Ice Cream Mix and Other Developments in the Ice Cream Field

In the opinion of Colonel Rohland A. Isker, former director Q.M.C. Subsistence Research and Development Laboratory, when discussing the acceptability of food by the American soldier, some foods inherently have a high morale value. He stated that bread, milk, potatoes, ice cream, chicken and cheese were favorites. (38) The manufacture of dry ice cream mix in large quantity for use by the armed forces during World War II was the greatest single achievement of the American dairy industry during the war, according to Colonel Isker. (39) Since the war, and particularly since sugar has become more available, dry ice cream mix has been marketed in small packages through food stores. The Army still uses large quantities. The U. S. Army Quartermaster Corps recently asked for bids on 19 million pounds of dry ice cream mix for delivery during April to September 1948. The commercial manufacture of dry ice cream mix is as follows: (40) (41)

1. The ingredients for spray drying can be combined in the following ways: (a) the fluid milk-cream mixture is adjusted to the desired ratio of fat to solids-not-fat prior to condensing. After condensing, the stabilizer, whipping agent and part of the sugar is added. The stabilizer is usually dissolved in hot water prior to adding to the mix in this method. (b) the fluid milk-cream mixture is adjusted to the desired ratio of fat to solids-not-fat prior to condensing as in (a) above, but the stabilizer, whipping agent, and 25 per cent of the sugar is added before condensing. All the sugar is not added to the mix before drying for the following reasons: 1. increases difficulties of drying; 2. decreases capacity of the drier; 3. a caramel-like flavor may develop in the dried mix.

2. The prepared mix or the fluid milk-cream mixture should be preheated to a relatively high temperature especially if the powder is to be gassed and kept for any length of time. A temperature of 170° F. for 20 minutes, 180° F. for 10 minutes, 190° F. for 5 minutes, or momentary holding at a high temperature may be used.

3. If the condensing method of making the mix is used the liquid ingredients are condensed to a 30 to 36 per cent total solids depending on whether the stabilizer is added before or after condensing and the viscosity of the mix.

4. If continuous operation is desired the mix is brought to 150° F., the stabilizer is added in a water solution and the mix is homogenized (2500 pounds first stage, and 500 pounds second stage).
5. The fluid mix should be pre-heated to 150° F. before spray drying.

6. The mix should be spray dried to contain not over 1.5 per cent moisture. The inlet temperature should be as low as possible to obtain this moisture as high inlet temperatures tend to give powder a cooked, scorched flavor.

7. For cooling, the powder must be removed continuously from the drying chamber and cooled to at least 100° F. before packaging in barrels or tins.

8. The remainder of the sugar is added to the powdered mix to obtain the desired sugar-fat ratio. Powdered vanilla is usually added to the mix at this time also.

9. The powdered mix is usually packaged in 25-pound tins and in tins holding 4-pounds 6-ounces of powder. The containers are then gassed to contain a minimum of oxygen.

Additional information regarding the manufacture of dry ice cream mix was given in a recent article in Food Industries. (42)

The continuous, high temperature method of pasteurization of ice cream mix was shown to be satisfactory several years ago, but it is only in recent years that this method has been introduced by the ice cream industry for pasteurizing ice cream mix. It has been reported that the method has been approved by at least two state regulatory departments. Equipment for heating ice cream continuously to a high temperature without burn-on are now on the market. One nationally-known ice cream authority has stated that this method of pasteurization is one of the outstanding developments of the past few years. A Ste-Vac heater will heat, if installed and properly operated, fluid products to 190° F. in a one stage operation and to as high as 240° F. in a two stage operation, and concentrated products from 40°F. or less to as high as 190° F. in a two stage operation. No "burn-on" takes place. (43) The Vacreator* vacuum pasteurizer which has been manufactured in the United States since the war, is used for heating cream for butter, ice cream mix, and market cream, instantly by steam in a chamber to a temperature of 190° - 200° F., followed by a treatment in two vacuum chambers maintained usually at about 20 inches and 28 inches vacuum. The product emerges from the third chamber at about 100° F. Low bacteria counts and negative phosphatase tests of the products were obtained in tests made. (44) The Vacreator is now being

* Vacreator, a trade-mark registered U.S. Patent Office, Canada and other countries.
used for the treatment of milk to be used in the manufacture of cheese. The milk is first preheated to a temperature of not less than 145°F, followed by treatment in the Vacreator at a maximum temperature of 165°F to 170°F. Since the milk emerges from the third chamber of the Vacreator at a temperature of about 100°F, it needs to be cooled only 15°F to the "setting" temperature.

The announcement of a method of first condensing milk for ice cream mix with a Vacreator followed by high temperature pasteurization at 195°F - 200°F of the complete homogenized mix in the Vacreator was released in 1946. (45) When condensing, a maximum of 500 pounds water per hour could be removed from the milk with the "Baby" size Vacreator and 100 pounds per hour with the "Junior" size machine. At the University of Manitoba 41,000 pounds condensed skim milk containing 28 per cent total solids have recently been made by this method. The product was sold to ice cream manufacturers. Condensing the complete mix with the Vacreator to the desired concentration followed by homogenization and vacreation of the mix has also been found satisfactory.

Utilization of the method of determining the true lactic acid content of ice cream as a means of determining the quality of ice cream was recently announced. The results from such an analysis would aid in determining whether the ice cream was made from fresh sweet milk or cream or from soured products. In the studies made it was found that the colorimetric method was accurate generally within 2 mg per cent. No relationship was found to exist between the lactic acid content and the titratable acidity and pH of the mixes. It was concluded that fresh, unflavored ice cream mix should contain less than 10 mg per cent (0.01%) of lactic acid as measured by the colorimetric method. (46)

Recent research on the use of high quality spray process dry whey solids in ice cream has shown that up to 7 per cent of the product could be used in vanilla ice cream and as much as 10 per cent could be used in chocolate and strawberry ice creams. (47)

New types of ice cream stabilizers and emulsifiers, or combinations of both, have been introduced since the war. The basic materials used for the stabilizers have, in general, not been changed. They consist mostly of gelatin, gums, sodium alginate, and Irish Moss. A recent stabilizer is sodium carboxy-methylcellulose. Emulsifiers, either added separately to the mix or in combination with a stabilizer, favor the formation of small air cells in the ice cream during freezing with the result that the ice cream will have a smoother texture. The ice cream appears "drier." The commercial emulsifiers consist of mono- or di-fatty acid glycerides; esters of fatty acids with sorbitan; or sorbitol; or esters of fatty acids and polyoxyalkylene derivatives of sorbitan. The addition of only 0.1 per cent emulsifier to ice cream mix has been observed to result in a considerable improvement in the texture of ice cream when a batch freezer was used. (48)
Miscellaneous Developments

The prevention of the development of an objectionable flavor in food fat when this is stored has been the subject for experimentation by food chemists for many years. A concerted effort was made during the war years to develop chemical agents that would act as inhibitors of the oxidation of fats. Partial lists of antioxidants have been prepared and the characteristics and the limitations of antioxidants as well as synergists have been discussed in the literature. The effectiveness of flavones and other phenylbenzopyrone derivatives as antioxidants for animal fats have recently been determined. It was found that the flavones querectin, querectin, and rutin were effective antioxidants for milk fat and lard. (49) A list of 51 references is given in the published report on this subject.

The development of a new dairy food was announced during the March 1948 meeting of the Federated Societies. The food consists largely of various milk solids supplemented with dried brewers' or cultured yeast, iron and calcium salts, vitamins A and D. The chemical composition is: Protein 21.8 per cent; fat 3.5 per cent; minerals 4.3 per cent; water 54.0 per cent. Non-reported ingredients 16.4 per cent. It was reported that the food can be served as fried patties in sandwiches, as dairy balls and loaves, with spaghetti, and as croquettes. The loaves and balls are claimed to have a distinct meaty taste. (50)

Changes in the method of merchandising ice cream have taken place. In a survey completed sometime ago it was found that about one-third of the total ice cream production was sold in packaged form as compared with only 20 per cent before the war. (51) Fewer retailers are willing to hand pack ice cream for take home sales. The survey showed that 82 per cent of those polled considered the grocery store the best outlet for their product; 64 per cent considered drug stores a satisfactory outlet; and 50 per cent reported using frozen food stores as regular outlets. Of the manufacturers that were doing a large package business, 75 per cent stated that a re-styling of the package for better eye and sales appeal was desirable.

The trend in merchandising ice cream for home consumption is in the sale of ice cream in attractive packages which the consumer can take home in insulated bags. Sometimes a small two- or three-ounce piece of dry ice is placed inside the bag. Buyers of food in food stores prefer factory packaged goods. They like to obtain the packages of frozen foods and of ice cream from the self service cabinets that are now extensively used in stores. When attractively displayed the sale of packaged ice cream may increase considerably as the product is still an "impulse buying" item. It was predicted (52) that if progress in merchandising continues the next few years, 75 to 80 per cent of ice cream will be consumed out of packages in the home.
It was also pointed out that many of the wide awake manufacturers are merchandising factory packed ice cream of approximately 70 per cent overrun, which conforms to what the public wants and in the past could only be found in dipped ice cream.

Improvement in the phosphatase test as a public health safeguard to assure consumers that the milk or cream used for bottling purpose or for manufacturing has been adequately pasteurized has recently been made. The test as improved has been adopted as an official method by the A.O.A.C. in October 1947, for use with fluid milk and cream, Cheddar cheese, and soft, unripened cheeses. (53)

Several methods of preparing dry milk fat have recently been developed. One of these, protected by a patent, (54) involves pasteurizing fresh, sweet cream at 170° - 180° F., then centrifugally separating this to obtain a high testing product containing 80 per cent fat, followed by homogenizing and passing the product through a settling tank. The fat when decanted contains about 2 per cent moisture and is freed from this moisture by passing through a centrifugal separator. If of high quality, dry milk fat will show little change when stored at 40° F. for six months. Dry milk fat has many uses. It can be used in place of butter; it is satisfactory for use in ice cream mix, cream cheese mix, creaming of cottage cheese, confections, baked goods, etc., and when combined with reconstituted nonfat dry milk solids, it can be used for the preparation of recombined milk, cream, butter, and ice cream. (55) Dry milk-fat has been shown to keep well when packed in inert gas with less than 0.50 per cent of the container volume as free and dissolved oxygen. (56)

Although not in the field of dairy research reference should be made to the development and wide use of the newer insecticides such as DDT and Chlor dane. The periodic application of these insecticides is effective in ridding dairy plants of flies and cockroaches. For the destruction of rodents has been invented a "Radar" trap. The apparatus is automatic and after the animal has been killed, without burning, with electricity, it is automatically expelled from the trap.

Wartime and postwar research has brought out new cleaning compounds and improved methods of cleaning dairy equipment. The cleaning agents now contain compounds that will emulsify fat, penetrate to the surface of the equipment, condition the water used, and react with the milk protein. The compounds should favor good rinsing. The newer commercial cleaning compounds are mixtures of several alkalis. Complex phosphate is generally present as is also one of the wetting agents. Special aluminum cleansers are available. For destruction of micro-organisms that remain on the cleaned equipment have been developed a group of quaternary ammonium compounds. The effectiveness of these germicides in various concentrations is being investigated. Several tests for determining the concentration of a number of these compounds have recently been developed. One method is based on formation of a red precipitate on addition of quaternary
ammonium compound to eosin yellowish and subsequent titration to a colorless compound with anionic surface active agent. (57) The test suggests wide applications for determining the concentration of dilute quaternary ammonium solutions. It also may be used to detect the presence of quaternaries in raw milk. A paper test where only rough estimations of quaternary concentrations are desired was also developed.

Advances in improving materials for dairy equipment are continuously being made. A new stainless steel "No. 20" has recently been developed. It is stated that the metal is very corrosion-resistant as it contains 3 per cent copper in so-called cold solution. The copper is not soluble and does not affect the quality of milk or cream with which it comes in contact. The composition of the metal is: carbon 0.07 per cent; manganese 0.75 per cent; nickel 29 per cent; molybdenum 2 per cent; silicon 1 per cent; chromium 20 per cent; copper 3 per cent; and the remainder iron. (58)

In addition to the many developments that have been discussed above, several others can be mentioned. They are: Coil pasteurizing vats equipped with sanitary rotary seals for coil shafts; improved construction of continuous ice cream freezers; automatic equipment for manufacturing chocolate coated bars; improvement in the construction of milk and cream pumps; automatically operated self-contained steam generators; automatic dispensers for bottled milk and packaged ice cream; improved ice cream packaging equipment; the use of aluminum foil for the wrapping of butter; improved gaskets for plate pasteurizers and for sanitary milk pipes; new equipment for reconstituting dry milk and for combining dry milk, butter oil and water; improved ice cream and cheese package design; an improved all electric automatic continuous milk pasteurizer; new paints that are mold resistant, acid and alkali resistant, and non-blistering when painted on damp surfaces; all-metal cheese vats and hydraulic metal cheese presses; a new refrigerant for keeping packages of milk, cheese, ice cream fresh during transit -- the light-weight bricks or bags can be re-activated and used again; home electric pasteurizers.

REFERENCES


42. Corbett, W. J., Powdered Ice Cream Mix. Food Industries, 20, No. 4, April 1948.

43. Private communication from C. M. Minthorn, Chester Dairy Supply Co., Chester, Pa., April 30, 1948.

44. Wilster, G. H., The Vaconator - For Pasteurizing, Deaerating and Condensing. Food Industries, 17, pp. 1152-1155 and 1282, 1945.


