Operation and Management Guides for a Dairy Manufacturing Plant

Mohammad Valanejad
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OPERATION AND MANAGEMENT GUIDES FOR A
DAIRY MANUFACTURING PLANT

by

Mohammad Valanejad

A report submitted in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Dairy Manufacturing Plan B

UTAH STATE UNIVERSITY
Logan, Utah

1965
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The author also appreciates the help given through products and demonstrations by the various branches of the dairy industry.

This report is dedicated to my father Mahmoud Valanejad who made my studies possible.

Mohammad Valanejad
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INTRODUCTION

The dairy and food industries have become highly technical and almost completely mechanized. They also ranked as one of the greatest industries in the country at the present time and represent an investment of many billions of dollars.

The rigid health department regulations, together with the special processes required, call for many types of specialized equipments and procedures. Most of the processes require heat, power, and refrigeration. More exact control of processes, as well as more efficient operation, have become increasingly important as these industries have matured and as competition has become keener. Material handling and automation are major developments in the modern milk or food processing plant.

The purpose of this handbook is to compile procedures, tables, directives, recipes, and formulas to help and guide in the operation of the plant and manufacture of dairy products. The care, operation and maintenance of plant equipments, layout, management practices, and reference tables used in the plant are also provided.
MARKET MILK AND RELATED PRODUCTS

Market Milk Processing (25)

"Milk" is defined to be the lacteal secretion obtained by the complete milking of one or more healthy cows, excluding that obtained within 15 days before and 5 days after calving, or such longer periods as may be necessary to render the milk practically colostrum free. Market milk is milk for distribution for consumption as milk and shall contain not less than 3.2 per cent of milkfat, and not less than 8.3 per cent of milk solids not fat.

Methods of Pasteurization

1—The vat method of pasteurization is heating every particle of milk to at least 145 F. and holding it at this temperature for at least 30 minutes in approved and properly operated equipment.

2—The high-temperature short-time method of pasteurizing milk consists of heating the milk to at least 162 F. and holding it at such temperature for at least 16 seconds. A few years ago, this method was known as "flash pasteurization."

Homogenization

A liquid is homogenized by passing through the valve of a machine known as a homogenizer. In order to secure efficient homogenization and thus produce a
product that will meet the U. S. Public Health Service Standard, the operator
must control a number of factors. Among the most important of these are the
following:

1—Homogenization pressure. The market milk could be homogenized
at a pressure of about 2500 pounds per square inch. A uniform, steady pressure
is necessary to secure satisfactory homogenization. In case air is drawn into
the cylinder block it causes the needle of the pressure gauge to vibrate. Such a
result indicates irregular pressure.

2—Condition of the homogenizer valves. The valve parts are subject
to extreme abrasion because of the high velocity and pressure of the fluid passing
through them. It is necessary, at intervals, to grind the valves in order to main­
tain a smooth surface and efficient homogenization.

3—Temperature. The temperature of homogenization is an important
factor in obtaining satisfactory results. Market milk or related products are
homogenized better when the temperature of fat in these products is 20-30 F. above
the melting point of fat. Commercial practice with the holding method of pasteuri­
zation is to homogenize the milk at 140 F. With the high-temperature method of
pasteurization the milk may be homogenized at a temperature between 130 F.—
140 F. after it leaves the regenerative section of the pasteurizer. After homoge­
nization it is then immediately passed through the final heating section of the
pasteurizer. The final heating inactivates the lipase enzyme and thereby prevents
the development of rancidity in the homogenized milk.
The Cooling of Milk

The cooling of milk to prevent bacterial growth has been emphasized as an essential factor in producing milk of low count. The latter part of pasteurization process includes the cooling of milk and cream to a low temperature immediately after the holding period. The pasteurized product is then kept cold until it is delivered. Thus, from the farm to the consumer, refrigeration is important.

Therefore, pasteurized milk should be cooled to between 35 and 40 F., bottled immediately, and stored at such temperatures until delivery.

Whipping Cream (25)

Cream is that portion of milk, rich in milkfat, which rises to the surface of milk on standing, or is separated from it by centrifugal force, is fresh and clean and contains not less than 18 per cent of milkfat.

To the consumer, usually, a large volume of cream in bottled unhomogenized milk means a high milkfat content; a small cream volume, a low milkfat content. Dealers, in many instances, have promoted this idea in an attempt to secure new business.

Cream can be pasteurized in two ways: (a) Heat the cream to 145 F. with as little agitation as possible, hold it for 30 minutes, and cool it to 40 F. or lower. (b) Heat the cream to 160-165 F. then hold at that temperature in a vat for 30 minutes, followed by batch cooling. This is a combination of flash heating and batch holding and cooling.
Factors important in whipping are as follows:

1—Chill the bowl and the whipper before adding the cream. Keep the cream cold before and during whipping.

2—Do not whip more cream than is suitable for the whipper used.

3—Use a bowl suited in shape to the type and size of the whipper.

4—Turn the agitator rapidly.

5—Whip to maximum stiffness, but do not overwhip.

6—For good whipping the fat content of cream should be at least 35 per cent.

**Chocolate Drink**

Recipe containing 2 per cent fat and 16.03 per cent total solids

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
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<tr>
<td>Milk (homogenized, 3.4 per cent fat)</td>
<td>58.83 %</td>
</tr>
<tr>
<td>Skimmilk</td>
<td>33.15 %</td>
</tr>
<tr>
<td>NFDMS</td>
<td>2.00 %</td>
</tr>
<tr>
<td>Sugar</td>
<td>5.00 %</td>
</tr>
<tr>
<td>Cocoa</td>
<td>0.88 %</td>
</tr>
<tr>
<td>Cocoloid</td>
<td>0.14 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.00 %</strong></td>
</tr>
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</table>

Chocolate drink varies considerably in composition according to the formulas used by the different distributors. The product may be consumed instead of milk by those who prefer its flavor, or it may be sold to consumers
who prefer to purchase a chocolate beverage instead of preparing one in the home (25).

Pasteurization

Heat the milk, skimmilk and NFDMS to 165 F., then mix in cocoa, cocoloid and sugar together. Hold for 30 minutes and cool immediately. Agitator should be running during heating, holding, and cooling periods, but as soon as the product has reached to 50 F or below stop agitation. For better and improved flavor 2 ounces of vanilla could be added to the drink after cooling. Bottle and store at 40 F or lower.

Directions for Making Butter (31)

1—Standardize the cream so it will contain 36 per cent fat.

2—Pasteurize at 165 F for 30 minutes and cool to 46-50 F. in the same vat and hold overnight.

3—Rinse the churn, which has been previously cleaned and sterilized, with chlorine at 200 ppm.

4—Drain the churn thoroughly. The buttermilk outlet should be properly closed.

5—Temper the cream until it reaches the desired churning temperature. This temperature ranges between 46-52 F. in the summer, and between 50-56 F. in the winter. The churning time is about 40-50 minutes.
6—Place the cream in the churn and add the butter color according to the directions on the color container.

7—Fasten the churn door securely and place the churn in gear and allow it to revolve for 2-4 times. Stop the churn and open the air release valve so that the pressure which has been built up inside the churn can escape.

8—Continue churning until the spy glass is washed clear by the buttermilk that forms.

9—Check carefully from this point until the granules reach the size of cracked corn.

10—With the door closed, turn the churn so that the buttermilk outlet is near the top. Open the outlet and insert the screen. Close the outlet and turn the churn so that the buttermilk outlet is at the bottom.

11—Open the buttermilk outlet and drain the buttermilk.

12—Spray cold water (as cold as possible) from the hose over the butter granules. Continue water addition until the water that runs from the outlet is practically clear.

13—Close the buttermilk outlet and add a volume of cold water equal to the volume of buttermilk removed. This water should be cooled with ice to 40 F.

14—Wash the butter for 5-6 minutes and drain the water from the churn.

15—Work the butter until it forms one mass and the churn becomes practically free from the moisture.
16—Take small portion of butter from three different areas in the churn and place in an air tight screw cap dry sample bottle. Keep the bottle cap in place except when mixing and sampling the butter.

17—Determine the moisture content.

18—Calculate the amount of water needed to standardize the moisture to the proper amount as follows:

Multiply the difference between the moisture content and the desired moisture content by the factor 1.5 for each 100 pounds of fat in the churn.

The arbitrary factor "1.5" represent the ratio of churn yield on the basis of a 25 per cent overrun, times the corrective factor "1.2" (i.e., 1.25 X 1.2 = 1.5). The corrective factor "1.2" is an approximation of the ratio of the water required as figured by the mathematical formula, to that as figured by multiplying the pounds of finished butter by the difference between moisture present and moisture desired.

For example if the moisture content of the butter is 14.7 per cent and the desired moisture is 17.2 per cent, and the churn contains 81.5 pounds of butter the amount of water needed will be as follows:

$$17.2 - 14.7 = 2.5 \text{ per cent}$$

$$\frac{2.5 \times 1.5 \times 81.5}{100} = 2.06 \text{ pounds of water needed.}$$

19—Replace a portion of the water with good quality butter starter, at the rate of 1 per cent of the finished butter.
20—Calculate the amount of salt needed. Ordinarily it calls for 2.5 pounds of salt for 100 pounds of butterfat. Thus 81.5 X 0.025 = 2.03 of salt needed.

21—Trench the butter in the churn. Place the salt and water in the trench and cover it with butter. Work the butter until the moisture and butter are evenly and completely incorporated.

22—Remove the butter from the churn by means of sterile paddles and place the butter in a butter box which has been sterilized and lined with sanitized parchment paper.

23—Tamp the butter into tub tightly so that air pockets will not be present in the butter.

24—Place the butter in the cooler at 40 F. overnight.

25—Cut the butter on the Simpson cutter. Check each print for weight and wrap with heat-treated or chlorine treated parchment wrappers.

Package in paraffined cartons.

26—Pack in 30 pound cases and place in the hardening room.

27—Date each case with the churning date.

28—Make out a butter churning report.
ANALYSIS OF BUTTER (17)

Moisture Determination

1—Have the moisture balance set level and swing freely and protected from drafts and vibration.

2—Place the riders on the two lower beams at the extreme left of the balance.

3—Place a clean dry aluminum cup (at room temperature) on the right hand pan of the balance by using the tare weights on the beams.

4—Place a 10 gram weight on the left hand pan of the balance.

5—With the aid of a spatula weigh 10 grams of butter directly and as quickly as possible into the aluminum cup.

6—Place the aluminum cup on the electric hot plate by the use of a tong.

7—Rotate the cup at intervals to break up the foam so as to avoid spattering and permit inspection of the color.

8—Continue heating until foaming has ceased and an amber color is obtained and the curd is a light golden brown.

9—Cool the cup at room temperature.

10—Re-weight the cup by moving the riders on the two lower beams until a balance is reached.

11—Read the percentage of moisture direct from the beams. These beams are graduated in grams so the reading can be made direct.
Fat Determination

1—Remove the beaker (cup) with the dried butter without disturbing the adjusted moisture counter balance.

2—Mix the dried butter sample with 100 ml. of petroleum ether by stirring thoroughly with a glass rod. Remove the glass rod and leave the beaker with the contents undisturbed for 3 or 4 minutes, and decant the ether dissolved fat.

3—Repeat the extraction using 50 ml. of petroleum ether.

4—Warm the aluminum beaker very slowly by holding it above the hot plate.

5—Heat until residue is dry, free from solvent odor, and powdery in appearance.

6—The beaker is then cooled, dried as before, and replaced on the scale, and balanced, milkfat counter-balances being used.

7—Read the percentage of milkfat directly from the calibrated milkfat beams, the counter-balances of which were adjusted to balance the loss in weight of fat extracted by the petroleum ether.

Salt Determination

1—The beaker (cup) is then rinsed 3 or 4 times with hot distilled water into a 250 ml. measuring flask. Such rinsings are made up to volume with distilled water and mixed thoroughly by inverting the flask several times.
2—Pipette 25 ml. of the water extract into a beaker or white porcelain cup. Add 2-3 drops of potassium chromate indicator and titrate with the standard silver nitrate solution to a permanent brownish red color. Each cubic centimeter of silver nitrate solution used is equivalent to 1 per cent of salt in the sample. Thus, if it required 3.5 ml. of the silver nitrate solution the sample contained 3.5 per cent of salt.

Note: The percentage of curd is determined by subtracting the sum of moisture, fat, and salt (in the case of salt butter) percentages from 100.

**Procedure for pH of Butter Sera**

1—Heat about one-quarter pound of butter in a flask to a temperature of 115-125 F. in a water bath, so that the butterfat melts and rises to the top while the serum settles to the bottom. The sample should not be agitated during this period. When separation is complete, remove the serum by plunging a pipette to the fat layer and draw up the serum, which should then be placed in a 30 ml. beaker and whirled for 3 minutes in a Babcock centrifuge.

2—Place the beaker containing the serum in a refrigerator for approximately 2 hours, which will permit any fat remaining in the serum to rise to the top and harden.

3—After the fat has formed a hard layer, plunge a pipette through it and draw off all serum possible, transferring it to an absolutely
clean 30 ml. beaker. Warm the serum to 77 F. before making the pH determination.

**Yeast and Mold Counts of Butter**

**Preparation of dilutions**

Warm the sample of butter contained in the sterile jar, as well as a sterile water blank, to about 104 F., in a water bath of 109-113 F. The time required for melting the butter should not exceed 15 minutes. Agitate thoroughly to obtain uniform mixing of the serum, water, and fat. With a previously warmed, sterile 10 ml. pipette, transfer 10 ml. of butter to a 90 ml. sterile water blank, (temperature of water 98-104 F.). Shake this dilution 25 times in the usual manner just before inoculating petri dishes with the different dilutions in duplicate. The suggested dilutions are, 1:2 (5 ml. of 1:10 dilution); 1:10 (1 ml. of the 1:10 dilution) and 1:100 (0.1 ml. of the 1:10 dilution).

**Incubation and colony counting**

The petri dishes containing the different dilutions are flooded with the melted, adjusted potato dextrose agar. Not more than 30 minutes should elapse from the time of preparing dilutions to the pouring of the potato dextrose agar on the plate. After solidification of the agar the plates are incubated for 5 days at 70-72 F.

At the end of the incubation period count the yeast and mold colonies in the same manner as counting bacterial colonies in the plate count for milk.
Generally, it is desirable to differentiate between molds and yeasts. The yeasts colonies are usually characterized by their profuse growth of hypae. The acidity of the medium is supposed to inhibit the growth of bacterial colonies. Usually these can be distinguished from the yeast colonies because they are smaller.
FERMENTED DAIRY PRODUCTS

Cultures and Starters (26)

The term "starter," as used in this connection, is understood to refer to cultures of desirable bacteria that produce lactic acid when inoculated into the milk, cream or other products. To be sure, small amounts of other products are produced, such as acetic acid, propionic acid and possibly others, but lactic acid is the principle fermentation product. Acid production usually will occur without the use of starter, but the results will be erratic.

Characteristics

Factors which are generally considered of prime importance in lactic cultures are as follows:

1—Purity of cultures, type of lactic strains and phage sensitivity.
2—Ability of acid production, and the type of acid produced.
3—Type of curd formed, whether light, medium, or heavy body.
4—Gas production.
5—Flavor producing properties.

Preparation of starter

1—Milk for mother culture must be sterilized to destroy even the most heat-resistant bacteria which might be in it. This is done by heating with steam
under pressure in a pressure cooker or autoclave. Holding the flask of milk under 15 pounds pressure for about 20 minutes gives the milk a slight, scarcely detectable, brownish color. When an autoclave is not available, heat the milk in steam bath or hot water bath from 190-200 F. for 60 minutes. Spores of some bacteria can endure this heat treatment, but they are not likely to grow and cause trouble if the lactic culture is active and if the incubation temperature is held close to 72 F.

2—When this milk is cooled to 70 F. it is ready to be inoculated by the original culture at the rate of 1 per cent. The original cultures are manufactured in the form of liquid or dry powder. They should be of proper stains, free from contamination, and do not produce gas in the finished product. Some of the well known organism involved are S. lactic, S. diacetylactic, S. thermophilus, etc. Combination of two or more of these organisms will produce acid, flavor, aroma, and certain features in the fermented dairy products.

3—Stir the mixture briefly, but thoroughly, to blend the culture inoculation with the mix.

4—Ripen the inoculated milk until it thickens. This will take about 15 hours at 72 F and the acid will be approximately 0.80 per cent in skimmilk with 10 per cent total solids. Cool it to 40 F. or better to maintain activity.

5—The second transfer would be into bulk starter for making cheese or other cultured dairy products.

Freezing

The practice of freezing cultures is not new. It has been known for many
years that freshly-prepared liquid cultures will remain viable for several months when frozen. Not until recent years, however, has serious consideration been given to the use of frozen, liquid cultures for production of commercial quantities of cheese. Such starters may eventually be used in cheese factories and milk plants to avoid the cost and other problems of storing mother cultures.

Freezing and storing liquid cultures needs extra attention. The mother culture or any amount of bulk starters could be kept frozen in sterile containers varying in size from one-half pint to a quart size. Identification and date of freezing on the containers filled with cultures helps the operator to locate the proper type organisms he needs, and also reduces the chance to use wrong bacteria.

On the average the frozen cultures are good about 8 months if kept below -10 F. Frozen cultures are used in the manufacturing of a number of dairy products such as cultured buttermilk, sour cream, and many types of cheeses.

Bacteriophage and Antibiotics (22, 23)

Bacteriophage

The combining form "phage" in the word bacteriophage means "to eat." In other words, the substance called phage, for short, eats bacteria. It belongs to the class of substances known as "lysis" which are capable of dissolving bacteria. Bacteriophage probably is the most important cause of slow cultures. It still represent serious problems in assuring daily high activity in lactic streptococcus cultures.
It is commonly observed that the acidity develops normally in the intermediate or bulk starter for a short period of time after inoculation and then ceases to develop further acid. The bacteriophage particles in the plant air or on the equipment or from other sources have gained entrance to the milk used for the intermediate or bulk starter.

Occasionally in the race between the development of acid by the lactic acid bacteria and the growth of phage, the acidity may be deceptively normal and the milk may coagulate. This may be due to such factors as a low magnitude of initial phage contamination, the presence of a considerable proportion of resistant strain of lactic acid bacteria or the retardation of the development of phage by the rapidly increasing acidity. Such a culture, however, even though apparently normal, is heavily seeded with phage, and on the second transfer may develop no acidity at all.

Rotation of cultures, use of pairs cultures, improved sanitation of vats and tools, isolated culture room, properly sealed culture tanks, and greater care in transfer of cultures all have aided in reducing incidence of bacteriophage attack to lactic starter cultures.

**Antibiotics**

The problem of antibiotics started when they were introduced into the dairy field. Antibiotics in milk inhibit the growth of microorganisms used in the production of buttermilk, cottage cheese, and other fermented dairy products. Antibiotics may get into the milk through the teat canal by injection intermuscularly or into the blood stream and by feeding. The use of antibiotics in treating a
milking animal for any reason may result in antibiotics in milk.

A comparatively simple biological test which readily detect antibiotics can be made in 2 1/2 hours. The test employs an actively growing lactic culture and 2, 3, 5,-triphenyltetrazolium chloride (TTC).

**Procedure**

1—Place 10 ml. of raw milk to be tested in sterile test tube equipped with screw cap or rubber stopper. Prepare a similar 10 ml. sample from skimmilk or raw milk known to be free from inhibitory substances—a control sample.

2—Pasteurize at 176 F. for 5 minutes.

3—Cool to 98.6 F. and inoculate each tube with exactly 1 ml. of 1:1 dilution of a fresh active lactic culture. Mix the culture in the tube thoroughly and incubate at 98.6 F. in a water bath for 2 hours.

4—Following the 2 hours incubation add to each tube 0.3 ml. of 4 per cent TTC and mix in thoroughly.

5—Return the sample to the water bath (98.6 F.) for an additional 1/2 hour.

6—After the second incubation, remove the samples and compare the color with that of the control sample. Any sample distinctly lighter in color (less red) than the control sample is considered as containing inhibitory substances. A sample showing strong inhibition will show no color (17).
Buttermilk (28)

Standardization

Standardize the milk to contain 2 per cent fat. Homogenize whole milk could be used instead of cream to balance the fat percentage.

Formula

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk (homogenized 3.4 per cent fat)</td>
<td>59.0 pounds</td>
</tr>
<tr>
<td>Skimmilk</td>
<td>39.7 pounds</td>
</tr>
<tr>
<td>Buttermilk powder</td>
<td>0.5 pounds</td>
</tr>
<tr>
<td>Lactose</td>
<td>0.5 pounds</td>
</tr>
<tr>
<td>Sodium citrate</td>
<td>0.3 pounds</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0 pounds</strong></td>
</tr>
</tbody>
</table>

Procedure

1—Pasteurize the milk at 170 F. for 30 minutes or longer time, and cool to 70-72 F. This is the setting temperature.

2—At setting temperature add 1 per cent of either frozen lactic acid bacteria and 1 per cent of flavor producing organisms, or 1 per cent of freshly made culture containing both acid and flavor producing bacteria.

3—Break the curd at 0.82-0.90 per cent acidity or pH of 4.3-4.6, and cool immediately. For better and faster cooling run the water in the jacket one-half hour before breaking the curd.
4—After breaking the curd, salt and citric could be added to the product. The rate of adding salt is about 0.2 per cent and of citric acid (dry) 2.5 ounces/30 gallons of finished product.

5—Cool to 40 F or below, but do not freeze.

Sour Cream (29)

Selection and standardization of the cream base

Use high grade cream and standardize it to either 18 or 20 per cent fat.

The following recipes are for 18 and 20 per cent fat mixtures respectively.

Recipe for 18 per cent fat and 27.64 per cent total solids

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream 36 per cent</td>
<td>50.0 pounds</td>
</tr>
<tr>
<td>Skimmilk</td>
<td>46.0 pounds</td>
</tr>
<tr>
<td>Buttermilk powder</td>
<td>2.0 pounds</td>
</tr>
<tr>
<td>NFDM</td>
<td>2.0 pounds</td>
</tr>
<tr>
<td>Lactose</td>
<td>0.5 pounds</td>
</tr>
<tr>
<td>Sodium citrate</td>
<td>0.3 pounds</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0 pounds</strong></td>
</tr>
</tbody>
</table>

Recipe for 20 per cent fat and 28.59 per cent total solids

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream 36 per cent</td>
<td>55.5 pounds</td>
</tr>
</tbody>
</table>
Skimmilk 39.7 pounds
Buttermilk powder 3.0 pounds
NFDMS 2.0 pounds
Lactose 0.5 pounds
Sodium citrate 0.3 pounds
Total 100.0 pounds

Pasteurization

Pasteurize the base cream at 165 F. for 30 minutes.

Homogenization

Homogenize the pasteurize cream at 165 F. with double stage homogenizer at 2500 psi. Then cool to 100 F. and re-homogenize the cream at the same pressure double stage, that is 2500 psi.

Inoculation and incubation

Add 1-1.5 per cent of good cultured buttermilk without containing any gas producing organisms. Incubate at 70-72 F. for 12-14 hours till 0.60-0.65 per cent acidity or pH of 4.4 has been reached.

Cooling and storage

When the desired acidity and coagulation are reached cool the bulk or packaged sour cream to 40 F. Good results are obtained by storing after chilling to 40 F. for at least 12 hours before selling.
Aging or storage at a low temperature increases flavor and consistency. Store at 40 F. or lower but never allow to freeze. There are many procedures for preparing sour cream. Ripening in packages seems to be gaining in popularity because of the appearance of the final product and its ability to withstand transportation without the appearance of free whey.

**Cottage Cheese Short Method (30)**

1—Select high quality skimmilk standardized to 10 per cent SNF. Pasteurize at 162 F. for 16 seconds, or at 145 F. for 30 minutes, and cool immediately.

2—Set at 88 F.

3—Set with 5.5–6 per cent active starter with no gas production and good phage resistance. Rennet may be added with the starter or one hour after addition of starter. The rate to add rennet is 2cc to 1000 pounds of skimmilk. Commercial coagulator may be added instead of rennet.

4—Cut the curd when the whey has reached the pH of 4.6 and let stand 10–15 minutes. Add approximately 4 inches of water at 120 F. to the var prior to cooking.

5—Cook to 100 F. in 1/2 hour. Stir very gently and often enough to prevent matting during cooking.

6—Cook to 120 F. in the next 1/2 hour.

7—Raise cooking temperature to 130–135 F. in 15 minutes then hold until curd is cooked which is about 15 minutes.

8—Test the curd in cold water or with tester, then drain the whey.
9—Wash the curd with one water at 80 F., then the second water at 35-40 F. Curd is left in the vat overnight to drain with cold water running through the jacket. Better cheese is obtained if creamed about 2 hours after draining.

10—Add 2 pounds of creaming mixture to 3 pounds of dry curd and allow the curd to soak up the dressing before packaging.

11—Store at 40 F. or below without freezing.

Cottage cheese could be manufactured under the long method, but since a considerable time and efforts are involved to reach the desired acidity most of the manufacturers use the short method and obtain better product. Cottage cheese is made of skimmilk which contains small fraction of fat, but when the dressing with high fat percentage is added to the curd prior to packaging it increases the total fat content.

Cottage cheese dressing recipe for 13 per cent fat and 23.09 per cent total solids

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream 36 per cent</td>
<td>36.12 pounds</td>
</tr>
<tr>
<td>Skimmilk</td>
<td>61.37 pounds</td>
</tr>
<tr>
<td>Lactose</td>
<td>1.00 pounds</td>
</tr>
<tr>
<td>NFDMS</td>
<td>1.00 pounds</td>
</tr>
<tr>
<td>Salt</td>
<td>1.00 pounds</td>
</tr>
<tr>
<td>Stabilizer (locust bean gum)</td>
<td>0.01 pounds</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.0 pounds</td>
</tr>
</tbody>
</table>
Figure 1. Cheesemaking chart regular clock method (30)
Pasteurize the dressing at 165 F. for 30 minutes, and cool to 40 F. or better before using.

Cheddar Cheese Short Method (30)

1—Use pasteurized milk of good quality. Add color at 1 1/2 ounce/1000 pounds milk.

2—Add starter at 90 F. at the following rate:
   
   S. lactis 2.5 per cent
   S. thermophilus 1.5 per cent

3—Add starters to milk 30 minutes before setting.

4—Set with 3 ounces of rennet per 1000 pounds of milk at 90 F.

5—Cut the curd 30 minutes after setting.

6—Stir gently and start heating 15 minutes after cutting.

7—Heat to 100 F. in 30 minutes.

8—Drain 1/2 of the whey at 100 F.

9— Fifteen minutes later turn on steam.

10—Heat to 110 F. in 10 minutes.

11—Cook for 10 minutes at 110 F.

12—Dip

13—Mill the curd 30 minutes after dipping.

14—Salt 10 minutes after milling.

15—Hoop 10 minutes after salting.

16—Dress 30 minutes after putting in press.
17—Remove the cheese from the hoops next morning.

18—Place the cheese blocks (5 or 10 pounds) in special plastic bags and cryovac them.

19—Place each bag of cheese in hot scalding water for 6–8 seconds, and transfer to the cheese boxes. Water temperature should be at 180 F.

20—Storage temperature used for ripening generally range from 40-60 F. The humidity in the curing room should be approximately 70–75 per cent

**Colby Cheese** (30)

1—Milk of high quality is properly pasteurized at 162 F. for 16 seconds, or at 145 F. for 30 minutes, and then cooled to 86 F. for setting temperature.

2—Add 1 1/4 per cent selected starter propagated with two approved strains of S. lactis bacteria.

3—Color—add 1 1/4 ounces per 1000 pounds of milk.

4—Temperature of setting should be 86 F.

5—Add rennet 1 hour after adding starter.

6—Amount of rennet is about 4 ounces per 1000 pounds of milk.

7—Cut the curd same as cheddar, about 25–30 minutes after adding rennet.

8—Cook to 90 F. first 10 minutes, then increase 4 F. the next 10 minutes, and finally raise to 102 F.

9—Time of dipping is 2 1/4 after adding rennet.
10—Acidity of dipping—0.04 per cent increase in acidity above that at cutting.

11—When curd appears as whey is drawn, keep gently stirring cured to prevent matting while balance of the whey is withdrawn.

12—Stir curd with 60 F. water and then draw after 5 minutes. Continue to stir curd until dry, then add 3.5 pounds of salt per 1000 pounds of milk. Ground pimentoes, caraway seed or sage may be added at the time of salting at the rate of 1-1 1/2 ounces per hundred weight of curd.

13—Stir 1/2 hour after salting then hoop. Never let curd particles mat at any time before hooping.

14—Hoop and dress as in cheddar cheese making.

15—Cryovac as soon as removed from the press next morning.

16—Store at 40-60 F. and 70-75 per cent humidity, for curing.

**Monterey Cheese (30)**

1—Starter should be fresh, active, free from contamination, and S. diacetylactis.

2—Milk of good quality and properly pasteurized.

3—Temperature of milk at setting—88 F.

4—Amount of starter to add 1 per cent.

5—No color is added.

6—Add rennet 15 minutes after the addition of starter. Amount of rennet is about 3 ounces per 1000 pounds of milk.
7—Cut the curd about 25-30 minutes after setting, and allow it to stand 15 minutes before stirring.

8—Temperature of cooling—102 F.

9—Acidity at dipping—0.02 per cent above cutting acidity.

10—Time of dipping—2 hours after adding rennet.

11—When whey reaches top of curd in draining add cold water to reduce temperature of the curd and whey to 90 F., then drain off diluted whey.

12—Stir curd at all times as the last whey goes off until placed in hoops. This would prevent the curd matting.

13—Salt one-half hour after dipping. Control acidity at time of dipping and particularly at salting time. Acidity at this point should be 0.20-0.22.

14—Hoop 30 minutes after salting. Cheddar cheese hoops could be used.

15—Dress one-half hour after putting in press.

16—Next morning remove from the press and take off press cloth.

17—Cryovac and store as in colby cheese.

**Swiss Cheese (30)**

1—Clarify the milk as it is received, or warm it to 70-75 F. if desired.

2—Pasteurize the milk at 145 F. for 30 minutes, and cool to 40 F.

3—Add the starters as follows:

   a—Streptococcus thermophilus—called the coccus cultures.

   Rate to add is about 500-600 ml./1000 pounds of milk.
b—Lactobacillus bulgaricus—called the rod cultures. Rate to add is about 250-300 ml./1000 pounds of milk.

c—Propionibacterium shermanii (a propionic-acid-forming microorganism), responsible for the characteristic flavor and eye formation. Rate to add is about 15-20 ml. per 1000 pounds of milk.

4—Add the rennet when the temperature of milk is 88-94 F. at the rate of 1.5-3 ounces per 1000 pounds of milk.

5—Cut the curd after 30 minutes of adding rennet. The cutting is done by a Swiss-cheese harp, from back to front and from side to side. Harp the curd (cut and mix) until the particles are about 1/8 inch in diameter. This usually requires about 15 minutes.

6—Then the curd is "foreworked"—that is, stirred slowly, either continuously or at intervals—for 30 minutes to an hour or more as it requires firmness.

7—When the curd is sufficiently firm steam is turned on and the curd is heated, usually in 30 minutes, to a temperature between 120-127.5 F. Stir the curd while heating and continue for at least 25 minutes and sometimes for an hour or longer after the final cooking temperature is reached.

8—Dip the curd, but pay attention that none of the curd is drained out. Then transfer the curd into the hoops, and press for 1/2 hour.

9—Dress the cheese after removing from the press.

10—Remove the cheese from the press next morning and place the cheese in brine solution for 203 days. The strength of the salt solution is
approximately 23 per cent salt (sodium chloride) in water. Turn the cheese over daily and sprinkle with salt. Then place the cheese in curing room (cold room) for 10 days.

11—Transfer the cheese after 10 days to a room with temperature of 65-72 F., and relative humidity 80-85 per cent. Keep it in curing room from 4-8 weeks, then it is taken to the cold room and held at 40 F. Following the curing period in the cold room, the cheese is ready to be graded and sold.
PROCESSSED CHEESES

Swiss-Italian Spread

Recipe

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monterey cheese</td>
<td>15.0 pounds</td>
</tr>
<tr>
<td>Swiss cheese (aged)</td>
<td>13.0 pounds</td>
</tr>
<tr>
<td>Provolone or Smoked cheese</td>
<td>4.0 pounds</td>
</tr>
<tr>
<td>Cream 36 per cent</td>
<td>8.0 pounds</td>
</tr>
<tr>
<td>Water</td>
<td>3.0 pounds</td>
</tr>
<tr>
<td>NFDMS</td>
<td>6.0 pounds</td>
</tr>
<tr>
<td>Sodium citrate</td>
<td>0.5 pounds</td>
</tr>
<tr>
<td>Disodium phosphate</td>
<td>10.0 ounces</td>
</tr>
<tr>
<td>Sorbistat</td>
<td>0.5 ounces</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50.0 pounds</strong></td>
</tr>
</tbody>
</table>

Procedure

1—Clean and grind the cheese.

2—Place cheese in cooker.

3—Mix in NFDMS and sorbistat.

4—Mix in sodium citrate, disodium phosphate, salt, and cream.

5—Heat to 160 F. and hold for 15 minutes.

6—Package directly from the cooker into the containers.
Aged Cheddar Club

Recipe

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aged cheese</td>
<td>60.0 lbs</td>
</tr>
<tr>
<td>Butter</td>
<td>5.0 lbs</td>
</tr>
<tr>
<td>Sorbistat</td>
<td>1.0 lbs</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>65.0 lbs</td>
</tr>
</tbody>
</table>

Procedure

1—Select and clean and grind the cheese.
2—Grind the butter.
3—Mix the cheese and butter in a cheese vat.
4—Run the mixture of cheese and butter through the grinder again and pack directly into the cans.

Note: Use same procedure for vintage club, except add 1/2 gallon of wine to the above amount of cheese while in the cheese vat.

Blue Cream Spread

Recipe

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream 36 per cent</td>
<td>56.0 lbs</td>
</tr>
<tr>
<td>NFDMS</td>
<td>4.0 lbs</td>
</tr>
<tr>
<td>Blue cheese</td>
<td>20.0 lbs</td>
</tr>
<tr>
<td>Ground agar or (0.30 pounds gelatin plus 0.20 pounds locust bean gum)</td>
<td>0.50 lbs</td>
</tr>
</tbody>
</table>
Dry citrus acid 2.00 ounces
Sorbistat 1.00 ounces
Salt 4.00 ounces
Total 81.0 pounds

Procedure

1—Heat the above mixture to 185 F. and hold for five minutes. Stir frequently until temperature is reached.

2—Strain through an ordinary mesh wire strainer.

3—Homogenize at 3500 psi at processing temperature.

4—Run into packages or plastic containers from homogenizer and cool.

If this is not possible to fill the containers from homogenizer, then it is advisable to use a can filler.

5—Melted paraffin may be poured on top of cooled cheese in crocks or plastic containers. Cheese may be poured into cans and sealed.

Garlic Cheese Spread

Recipe

Mild cheese 16.0 pounds
Aged cheese 20.0 pounds
NFDMS 5.0 pounds
Water 9.0 pounds
Sodium citrate 12.0 ounces
Disodium phosphate 12.0 ounces
Salt (garlic salt) 8.0 ounces
Sorbistat 1.0 ounces

Total 52.0 pounds

Procedure

1—Clean and grind the cheeses.

2—Place one-half of the cheese in the cooker and turn on steam slowly.

3—Add 3 to 4 pounds of water.

4—Add the NFDMS.

5—Add remainder of water and cheese.

6—Add salt, sodium citrate and disodium phosphate, and sorbistat.

7—Cook at 155-160 F. and package directly from the cooker.

Note: If proper consistency has not been reached, add sufficient water.

Onion Cheese Dip

Recipe

Monterey or Jack cheese 16.0 pounds
Aged Swiss cheese 12.0 pounds
Cream 36 per cent 38.0 pounds
Skimmilk 13.0 pounds
Sodium citrate 8.0 ounces
Dariloid 2.5 ounces
Citric acid 2.5 ounces
Locust bean gum 1.5 ounces
Onion salt 6-8 ounces
Sorbistat 1.0 ounces
Total 80.0 pounds

Procedure

1—Clean and grind the cheese.
2—Place cream and skimmilk in a 10 gallon can.
3—Mix in citrate, citric acid, locust bean gum, and sorbistat.
4—Mix in cheese.
5—Heat to 165 F. and add dariloid.
6—Heat to 180 F. and hold 15 minutes.
7—Add salt and acid after dariloid is dissolved.
8—Homogenize at 2500 psi single stage at 180 F.
9—Fill into crocks, bowls or cans.
10—Spread melted paraffin on the surface of containers and allow it to cool before sealing the containers.

Pimento Cheese Spread

Recipe

Aged cheddar cheese 24.0 pounds
Mild cheddar cheese 11.0 pounds
Ground pimento 5.0 pounds
NFDMS 5.0 pounds
Water 7.0 pounds
Sodium citrate 10.0 ounces
Disodium phosphate 10.0 ounces
Salt 10.0 ounces
Cayene pepper 1.5 ounces
Sorbistat 1.0 ounces
Total 54.0 ounces

Procedure

1—Clean and grind the cheeses.
2—Place one-half of the cheese in the cooker.
3—Turn on steam slowly.
4—Add 3 to 4 pounds of water.
5—Add the NFDMS slowly.
6—Add remainder of water and cheese.
7—Add salt, sodium citrate and disodium phosphate.
8—Add the pimentos.
9—Heat to 160 F. or 162 F.
10—Package direct from the cooker.

Note: If proper consistency has not been reached, add sufficient water.
ICE CREAM COMPOSITION AND COMMON FLAVORS

Ice Cream Composition

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
<th>Fat</th>
<th>S. S.</th>
<th>T. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFDMS</td>
<td>5.81</td>
<td>5.52</td>
<td>5.52</td>
<td></td>
</tr>
<tr>
<td>Cream 36 per cent</td>
<td>33.34</td>
<td>12.00</td>
<td>1.92</td>
<td>13.92</td>
</tr>
<tr>
<td>Skimmilk</td>
<td>45.15</td>
<td>4.06</td>
<td>4.06</td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>13.00</td>
<td></td>
<td>13.00</td>
<td></td>
</tr>
<tr>
<td>C. S. S. 24</td>
<td>2.50</td>
<td></td>
<td>2.50</td>
<td></td>
</tr>
<tr>
<td>Stabilizer (Dariloid)</td>
<td>0.15</td>
<td></td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Emulsifier</td>
<td>0.05</td>
<td></td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>12.00</td>
<td>11.50</td>
<td>39.20</td>
</tr>
</tbody>
</table>

The percentage of stabilizer and emulsifier used in ice cream and related products varies according to different procedures and the manufacturers recommendations.
Table 2. Using condensed skimmilk as the basis of serum solids

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Amount</th>
<th>Fat</th>
<th>S. S.</th>
<th>T. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensed skimmilk</td>
<td>23.81</td>
<td>7.14</td>
<td>7.14</td>
<td></td>
</tr>
<tr>
<td>30 per cent S. S.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cream 36 per cent</td>
<td>33.34</td>
<td>12.00</td>
<td>1.92</td>
<td>13.92</td>
</tr>
<tr>
<td>Skimmilk</td>
<td>27.15</td>
<td>2.44</td>
<td>2.44</td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>13.00</td>
<td></td>
<td></td>
<td>13.00</td>
</tr>
<tr>
<td>C. S. S.</td>
<td>2.50</td>
<td></td>
<td></td>
<td>2.50</td>
</tr>
<tr>
<td>Stabilizer</td>
<td>0.15</td>
<td></td>
<td></td>
<td>0.15</td>
</tr>
<tr>
<td>Emulsifier</td>
<td>0.05</td>
<td></td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>12.00</td>
<td>11.50</td>
<td>39.20</td>
</tr>
</tbody>
</table>

Common Flavors of Ice Cream

**Vanilla**

To each 5 gallon of the ice cream mix add 2 ounces of liquid vanilla and freeze.

**Strawberry**

To every 6 pounds of fresh strawberry add enough mix to make 5 gallons, plus 3/4 to 1 ounce of color (depending on the color strength) and freeze.
Chocolate

To 5 to 6 pounds of chocolate syrup add enough mix to make 5 gallons and freeze.

Maple nut

Two ounces of maple flavor (extract) for every 5 gallons of the mix plus small pieces of walnut fed to the fruit feeder. The amount of walnut ranges from 1 to 2 pounds or more per 5 gallons of the mix.

Butter brickle

One ounce of vanilla to every 5 gallons of mix to the freezer. As the frozen product is discharged from the freezer, butter brickle candy is added to it through the fruit feeder at the rate of 1.5 pounds per 5 gallons of the mix.

Lemon custard

Two ounces of lemon custard to every 5 gallons of the mix and freeze.

Banana

Three and one-half pounds of banana puree and mix to make up 5 gallon, plus 1 ounce of egg yellow color and freeze.

Orange pineapple

Three and one-half pounds of fine crushed orange pineapple mixture and
ice cream mix to make up a 5 gallon batch and freeze. There is no need to add color if the orange pineapple mixture contains color.

**Preparation of Chocolate Syrup for Chocolate Ice Cream**

**Recipe**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoa</td>
<td>6.00 lbs</td>
</tr>
<tr>
<td>Sugar</td>
<td>22.00 lbs</td>
</tr>
<tr>
<td>Whole milk</td>
<td>22.00 lbs</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>50.00 lbs</td>
</tr>
</tbody>
</table>

Mix the cocoa and sugar together then dissolve in the whole milk. Add 5 ounces of chocolate color if desired. Heat the mixture to 165°F. for 30 minutes, and then cool and store at 40°F. or below. Use at the rate of 5 to 6 pounds of this syrup for each 5 gallon of ice cream mix, and then freeze.

**Preparation of Colors for use in Ice Cream**

Heat 3400 ml. of distilled water to boiling and then cool to 180°F. Add slowly 4 ounces of the powdered color and stir vigorously. Place the solution in a clean sterile gallon container. Add 400 ml. of 95 per cent ethyl alcohol as a preservative. Avoid contamination of the color. Do not return any unused color to the container. Use amber glass containers so the solution will be protected from the light. Store the color solution in the refrigerator at not over 40°F.
ICE MILK MIX AND SOFT SERVE COMPOSITION

<table>
<thead>
<tr>
<th></th>
<th>Soft Serve Formula</th>
<th>Ice Milk Mix Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>5.00 per cent</td>
<td>5.00 per cent</td>
</tr>
<tr>
<td>Serum solids</td>
<td>13.00 per cent</td>
<td>14.00 per cent</td>
</tr>
<tr>
<td>Sugar</td>
<td>14.00 per cent</td>
<td>12.00 per cent</td>
</tr>
<tr>
<td>C. S. S. 24</td>
<td>1.00 per cent</td>
<td>5.00 per cent</td>
</tr>
<tr>
<td>Stabilizer</td>
<td>0.40 per cent</td>
<td>0.40 per cent</td>
</tr>
<tr>
<td>Emulsifier</td>
<td>0.30 per cent</td>
<td>0.15 per cent</td>
</tr>
<tr>
<td>Total</td>
<td>33.70 per cent</td>
<td>36.55 per cent</td>
</tr>
</tbody>
</table>
Table 3. Using NFDMS as the basis of serum solids for soft serve

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Amount pounds</th>
<th>Fat</th>
<th>S. S.</th>
<th>T. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFDMS</td>
<td>6.81</td>
<td>6.48</td>
<td>6.48</td>
<td></td>
</tr>
<tr>
<td>Cream 36 per cent</td>
<td>13.89</td>
<td>5.00</td>
<td>0.80</td>
<td>5.80</td>
</tr>
<tr>
<td>Skimmilk</td>
<td>63.60</td>
<td>5.72</td>
<td></td>
<td>5.72</td>
</tr>
<tr>
<td>Sugar</td>
<td>14.00</td>
<td></td>
<td></td>
<td>14.00</td>
</tr>
<tr>
<td>Stabilizer</td>
<td>0.40</td>
<td></td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>Emulsifier</td>
<td>0.30</td>
<td></td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>5.00</td>
<td>13.00</td>
<td>33.70</td>
</tr>
</tbody>
</table>

Condensed whole or condensed skimmilk could be used instead of NFDMS for soft serve and ice milk mix.

Table 4. Using NFDMS as the basis of serum solids for ice milk mix

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Amount pounds</th>
<th>Fat</th>
<th>S. S.</th>
<th>T. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFDMS</td>
<td>8.17</td>
<td>7.77</td>
<td>7.77</td>
<td></td>
</tr>
<tr>
<td>Cream 36 per cent</td>
<td>13.89</td>
<td>5.00</td>
<td>0.80</td>
<td>5.80</td>
</tr>
<tr>
<td>Skimmilk</td>
<td>60.39</td>
<td>5.43</td>
<td></td>
<td>5.43</td>
</tr>
<tr>
<td>Sugar</td>
<td>12.00</td>
<td></td>
<td></td>
<td>12.00</td>
</tr>
<tr>
<td>C. S. S. 24</td>
<td>5.00</td>
<td></td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Stabilizer</td>
<td>0.40</td>
<td></td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>Emulsifier</td>
<td>0.15</td>
<td></td>
<td></td>
<td>0.15</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>5.00</td>
<td>14.00</td>
<td>36.55</td>
</tr>
</tbody>
</table>
SHERBETS

A sherbet is a frozen product made from sugar, water, fruit acid, color, fruit flavoring, stabilizer and a small amount of milk solids added in the form of skimmilk, whole milk, condensed milk or ice cream mix.

**Composition**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>1.50 per cent</td>
</tr>
<tr>
<td>Serum solids</td>
<td>3.84 per cent</td>
</tr>
</tbody>
</table>

**Recipe**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole milk (homogenized 3.4 per cent)</td>
<td>44.12 pounds</td>
</tr>
<tr>
<td>Frodex 24</td>
<td>9.50 pounds</td>
</tr>
<tr>
<td>Sugar</td>
<td>20.00 pounds</td>
</tr>
<tr>
<td>Sherbet (stabilizer)</td>
<td>0.10 pounds</td>
</tr>
<tr>
<td>Gelatin</td>
<td>0.40 pounds</td>
</tr>
<tr>
<td>Water</td>
<td>25.88 pounds</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00 pounds</td>
</tr>
</tbody>
</table>

Adjust acidity of the mix to 0.65 per cent before freezing by addition of citric acid. If homogenized whole milk is used the entire mix need not be homogenized.
Common Sherbet Flavors

Lemon sherbet

Add 2 ounces of lemon emulsion to every 5 gallon base mix and freeze.

Orange sherbet

Add 2 ounces of orange emulsion to every 5 gallon base mix and freeze.

Pineapple sherbet

For every 3.5 pounds of well crushed pineapple add enough base mix to make a 5 gallon batch and freeze.

Strawberry sherbet

For every 6 pounds of fresh frozen strawberry add enough base mix to make up a 5 gallon batch and freeze. Strawberry color could be added to the rate of 3/4 to 1 ounce per 5 gallon.

Lime sherbet

Add 2 ounces of lime emulsion to every 5 gallon of base mix and freeze.

The above emulsions of lime, orange, and lemon should have enough coloring strength besides flavoring material.
Frappé

This special sherbet flavor is made in different flavors, such as pineapple, lime, and orange. The procedure is simple. To a 5 or 3.5 gallons of hard frozen sherbet add 2 to 3 bottles of plain carbonated beverage and serve. This flavor need not be frozen again.
BABCOCK TESTS FOR FAT IN MILK, CREAM, AND SKIMMILK (17)

Milkfat Test

Procedure

1—Temper the milk sample to 60-70 F. and mix thoroughly.

2—Measure 17.6 ml. of the milk into the Babcock pipette by adjusting the top of the milk meniscus to the level of the graduation line, and transfer the contents to the test bottle by allowing the milk to drain freely from the pipette, and then blowing the last drop from the pipette.

3—Add 17.5 ml. of Babcock sulfuric acid at 60-70 F. by tipping the test bottle and allowing the acid to flow gently down the neck of the bottle as it is being slowly rotated. Babcock sulfuric acid has a specific gravity of 1.82-1.825 at 68 F. (20 C), stored in tightly stoppered containers. Mix the acid and the milk with a gentle rotary movement of the bottle, by hand or by means of a mechanical shaker, until the milk solids other than fat are thoroughly digested. When curd particles are no longer visible and the bottle contents have assumed a dark chocolate color, the mixing may be regarded as complete.

4—Immediately place the test bottles in the centrifuge, taking care to balance the load and, maintaining a temperature of 135-150 F. in the centrifuge, whirl them for 5 minutes.

5—After the 5 minutes whirling, add water at about 140 F. to bring the level of the bottle contents to a point just below the lower end of the bottle neck. Centrifuge again for 2 minutes, and add water to bring the level to near the rop
of the graduated portion of the neck.

6—Centrifuge for 1 minute, and then immerse the bottle in a water bath 131-140 F. so that the water level of the bath comes slightly above the upper meniscus of the fat column. Allow the bottle to remain in the bath for 3-5 minutes.

7—Remove the bottles one at a time, wipe, and with dividers or calipers read the test directly by simultaneously measuring the length of the fat column from its lowest point to the highest extremity of its upper meniscus. Duplicate test should agree within 0.10 per cent. When there is any doubt regarding the accuracy of any test the sample should be re-tested in duplicate.

Cream Fat Test

Procedure

1—Balance clean 50 per cent 9 gram cream test bottles on the torsion balance.

2—Weigh into the bottles exactly 9 grams of a well mixed sample of cream using a 9 ml. cream pipette for transferring the sample. Adjust the sample to about 70 F. before weighing it.

3—Add 9 ml. of soft water to the weighed portion and mix thoroughly by the customary rotating motion.

4—Add slowly 17.5 ml. of Babcock sulfuric acid at 60-70 F. to the sample with a gently rotary motion or by means of the mechanical shaker until visible curd has been dissolved and the contents assume a coffee color.
5—Centrifuge samples for 5 minutes.

6—Add water to bring fat column to near the top of graduated scale.

The water temperature should be about 135-150 F.

7—Centrifuge 1 minute and place the samples in a water bath at 135-140 F. for not less than 3 minutes.

8—Just before reading, add 2-3 drops of glymol (red reader) to the fat column by allowing it to run down the side of the neck of the bottle. Remove the samples from the water one at a time, and read immediately. Make the reading by measuring the fat column from the bottom of the lower meniscus to the intersection of the fat and glymol.

**Skimmilk Fat Test**

**Procedure**

1—Adjust the skimmilk to a temperature of 60-70 F. and mix thoroughly by pouring several times from one container to another.

2—Fill the 17.6 ml. pipette to the mark and deliver the charge into the skimmilk test bottle through the large neck of the bottle.

3—Carefully add in 17.5 ml. of concentrated sulfuric acid, thoroughly mixing the acid. Excercise extreme care to prevent particles of the coagulated milk from entering the graduated neck as pressure may build up and would cause some of the contents to be ejected through the large neck.

4—Balance the test bottles in the centrifuge taking care to place the large neck toward the center of the machine, so that fat can be forced into the
graduated neck as a result of the centrifuging. Centrifuge for 10 minutes then add water (140 F. or above) to bring the level of the bottle contents to the base of the neck. Centrifuge 2 minutes and carefully add sufficient hot water to bring the fat up into the graduated column. Centrifuge again for 1 minute.

5—Place the test bottles in the water bath maintain at 135-140 F. for 3-5 minutes. Remove from the water bath one at a time, and read the test with the aid of the dividers.
TE SA BUTTERFAT TEST (17)

Procedure

1—Pipette 17.6 ml. of milk into side arm of special Te Sa test bottle.

2—Add 15 ml. of Te Sa reagent—methanol solution through the side arm of the Te Sa bottle and mix at once with a swirling motion for 10 seconds. (Prompt mixing is very important.)

3—Place test bottle in boiling water bath deep enough to cover the liquid in the bottle. Allow to remain for 10 minutes.

4—Fill the side arm of Te Sa bottle to the top with boiling water from the bath and let stand at room temperature for 5 minutes.

5—Transfer to tempering water at 140 F. deep enough to cover the liquid in the neck of the bottle. After 2 minutes read the fat percentage indicated in the center column from the bottom of the upper meniscus to the bottom of the lower meniscus. This may be done by adding water slowly to bring the fat column to zero, or by lowering the plunger rod in the side arm, raising the fat column to zero for direct reading.

6—Empty and clean Te Sa bottles by flusing with water.
FAT DETERMINATION BY MOJONNIER TESTER FOR MILK, ICE CREAM, AND CONDENSED MILK (17)

Milkfat Determination

Procedure

1—Mix the sample thoroughly by pouring several times from one vessel to another. The sample temperature should be about 70 F.

2—Weigh a 10 gm. sample into a properly labeled extraction flask using a 10 gm. pipette.

3—Add 1.5 ml. of ammonium hydroxide, concentrated and mix thoroughly. The ammonium hydroxide neutralizes any acid present and dissolves the casein.

4—Add 10 ml. of 95 per cent grain alcohol, insert the cork and shake for 1 1/2 minutes. The alcohol prevents the formation of a jelly or colloid like substance, which always forms when ethyl either is added without the presence of alcohol.

5—Add 25 ml. of ethyl ether, insert the cork, and shake for 1 1/2 minutes. The ethyl ether dissolves the fat.

6—Add 25 ml. of petroleum ether, insert the cork, and shake for 1 1/2 minutes. The petroleum ether takes out the last traces of moisture from the ethyl ether extraction and also aids in dissolving the fat.
7—Centrifuge 30 turns, taking 1/2 minute.

8—Pour off the ether mixture containing the extracted fat into a fat dish.

9—For the second extraction add 5 ml. of alcohol to the residue in the flask and shake. Then add 15 ml. each of ethyl and petroleum ether, inserting the cork and shake for 30 seconds after the addition of each reagent.

10—Centrifuge 30 turns, taking 1/2 minute.

11—Evaporate the ether from the fat dishes on the electric hot plate at 275 F. (135 C.).

Precaution

Ether fumes are dangerous and must not be allowed to spread through the room. Always keep the cover over the hot plate when evaporating the ether, and have the proper exhaust pipe taking the fumes from the tester to outdoors. Do not permit smoking in the laboratory as ether fumes are very inflammable.

12—Make a third extraction in the same manner as the second, omitting the addition of alcohol.

13—Remove the last traces of ether in the vacuum oven at 275 F. for 5 minutes with not less than 20 inches of vacuum.

14—Cool the dishes in the cooling desiccat or with the circulating water at room temperature for 7 minutes. If there are several dishes in the oven, it is advisable to increase the time of cooling to 10 minutes.
15—Weigh rapidly and record the weight of fat. All weight should be recorded to the fourth decimal place.

\[
\text{Percentage Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100
\]

**Ice Cream Fat Determination**

**Procedure**

1—Adjust the sample to room temperature and mix thoroughly by pouring several times from one vessel to another.

**Precaution**

Fruited ice cream samples containing nuts are difficult to sample. Care should be taken to get even distribution of fruits or nuts.

2—Weight a sample of about 5 grams (recording the weight accurately) into a properly labeled extraction flask.

3—Add 5 ml. of distilled water, mix well, and proceed as for milk except that 25 ml. of ethyl and of petroleum ether must be added in making the second extraction.

**Condensed Milk Fat Determination**

**Procedure**

1—Adjust the sample to room temperature and mix thoroughly by pouring several times from one vessel to another.
Note. In case of heavy superheated products and canned evaporated milk it may be necessary to warm the sample to 90-100 F.

2—Weigh a sample of about 5 grams (record the weight accurately) into a properly labeled extraction flask.

3—Add 6 ml. of distilled water and proceed as for milk except that 25 ml. of ethyl and petroleum ether must be added in making the second extraction.
BACTERIAL TESTS FOR DETERMINATION OF QUALITY AND KEEPING QUALITY OF MILK (17)

Standard Plate Count

Procedure

1—Arrange samples, dilution bottles and petri dishes in a convenient manner similar to the following diagram. Place initials and dilution factor on each petri dish.

![Diagram showing standard plate count procedure]

Figure 2. Methods of making various dilutions for bacteriological plating
2—Shake the milk sample rapidly 25 times, each shake being an up and down motion of about a foot. The time of shaking not to exceed 7 seconds.

3—Transfer 1 ml. of the sample to a 99 ml. sterile water blank using a sterile 1.1 ml. pipette, exercising care to avoid contamination. After the pipette has drained for 2-3 seconds, gently blow out the last drop. Recap the dilution bottle and shake as previously described. Higher dilutions can be made if needed. Next transfer 0.1 ml. of the diluted milk to the petri dish labeled 1/1000 and 1.0 ml. to the petri dish labeled 1/100. Hold the end of the pipette at an angle of 45 degree against the bottom of the dish until the pipette has emptied, then touch the pipette once against a dry spot in the dish to remove remainder of the liquid.

4—Sterilize the tip of the media container by direct exposure to the flame, and lift the petri dish cover just enough to permit pouring off the agar. Introduce 10-12 ml of liquified agar at a temperature of 42 C. and spread it evenly over the bottom of the dish carefully rotating the dish to mix the milk and agar.

5—After the agar solidified, invert the petri dishes and place them in the incubator at 32 C. for 48 hours. Place petri dishes in Quebec colony counter and count all visible colonies. Multiply the colony count by the dilution used to obtain the bacteria count of the original sample of milk. Report as the number of colonies per ml.
Coliform Count

Procedure

1—Arrange samples and petri dishes similar to the above diagram.

2—Mix the sample of milk as previously described, and pipette 1.0 ml. into each of two dishes.

3—Add to each petri dish 10-15 ml. of violet red bile agar which has been melted and kept warm. Mix carefully and allow to solidify, then pour an additional 4-5 ml. of the agar over each plate.

4—After the agar has solidified invert the plate and incubate for 18-24 hours at 32 C.

5—The presence of dark red colonies measuring at least 0.5 mm. in diameter constitutes a positive presumptive test. Count such colonies and record the results as the coliform count per ml. of milk.

Psychrophilic Count

Procedure

1—Prepare dilutions and petri dishes as outlined above under Standard Plate Count.

2—Incubate at 5-7 C. for 7-10 days.
Thermophilic Count

Procedure

1—Prepare dilutions and petri dishes as outlined above under Standard Plate Count.

2—Use 18-20 ml. of agar instead of 10-12 ml. as in the case of Standard Plate Count.

3—Incubate at 55 C. for 48 hours.

Crystal Violet Tetrazolium Count (CVT)

Milk dilutions

The CVT may be used successfully with dilutions of 1-10 but with lower dilutions the milk partially neutralizes the effect of the crystal violet and the counts are erratic. The recommended procedure is to prepare dilutions blanks with distilled water containing 10 ppm of crystal violet and dispense in 9 ml. quantities in screw capped test tubes or vials, with capacities of about 25 ml. and sterilize. Nine ml. of milk mixed with this quantity results in a 1-2 dilution. Place 1 ml. on each of two plates and record the total of the colonies developing on the two plates as the count per ml.

Incubation

Incubate at 90 F. (32 C.) for 48 hours. Incubation at 95 F. (35 C.) is too high for many of the organisms. Incubation of both Standard Plate
Count and CVT plates at 90 F. is the most convenient method. Somewhat better results can be obtained by incubating the plates poured with CVT agar at 75-85 F. for 3 days.

Interpretation

Since the CVT counts include the coliform along with other non-heat resistance contaminants, it is obviously much more sensitive than the coliform test for detecting contamination. It is particularly applicable for detecting the sources of contamination with the line tests, especially where a sample of milk from the pasteurizer of a lab pasteurized sample is plated along with other sample taken at various stages of processing. Occasionally colonies on the CVT agar may be due to types which survived pasteurization. A comparison of the CVT count on the milk from the pasteurizer with the count on the first carton filled will reveal the overall sanitary condition of the equipment. High CVT or psychrophilic counts or the absence of coliform do not necessarily mean that the milk will spoil rapidly but they do indicate that the door is open to contaminants that might cause rapid spoilage.
OPERATIONAL PROCEDURES FOR H. T. S. T.

1—Assemble the equipment properly and make sure all lines are tight enough to prevent any leaks.

2—Fill the balance tank with water.

3—Turn on the cold water valve by the homogenizer for cooling the cylinders. (A quarter of a turn or so would be enough).

4—Turn on the homogenizer and make sure the system is properly operating.

5—Add chlorine solution to the balance tank enough to sterilize the H. T. S. T. and all lines.

6—Fill the heat circulating tank with water and turn on the steam valve. (The heat circulating pump and air compressor should be on by.)

7—It takes about 10-15 minutes for water to reach to 162 F. and be allowed to pass through the flow diversion valve.

8—By the time the balance tank is almost empty allow the milk to get into it and turn on the cooling water into the H. T. S. T. It takes 1-1.5 minutes for milk to get into the homogenizer.

9—In order to homogenize the milk, pressure is applied up to 2500 psi or more at this stage.

10—It takes 3-3.5 minutes for milk to get pasteurized, homogenized, and cooled. Adjust the timing pump so water won't mix in with milk.
11—For further cooling the milk while getting out of the H. T. S. T. sweet water pump could be turned on.

Note. By adjusting the temperature on the panel board one could control it to any temperature above 162°F. Since this is a minimum temperature for H. T. S. T. in 16 seconds holding time.
OPERATION OF CONTINUOUS FREEZER

The operation of the continuous freezer demands care and management on the part of the operator. The following are the chief requisites for keeping the freezer operating properly.

1—Assemble the machine in proper way and make sure all mix lines and pumps are tight enough to prevent mix leaking out and air leaking in.

2—Drain oil from the ammonia jacket before starting the freezer.

3—Make certain that there is always a plentiful supply of ammonia at the freezer.

4—Sanitize all mix lines and freezing chamber and rinse afterwards. Use chlorine at 200 ppm.

5—Add the mix to the machine and let the refrigerant get into the freezing chamber.

6—Apply pressure inside the chamber and regulate air valve to get the desired overrun. Check the container's weight for proper overrun.

7—Adjust the temperature of the freezing so that the frozen product which is discharged from the machine is dry and not too hard (low temperature) to stop the operation.
Precautions

1—Check controls frequently to insure proper operation.

2—Never bend scraper blades. Never drop the freezer dasher. Be careful when removing it from the freezing cylinder.

3—Allow the freezing chamber to warm up prior to rinsing with water.

4—Check the pump motor to insure proper lubrication and tightness of belts.

5—Use extreme care in handling dasher in assembling or in dismantling the freezer in order to prevent personal injury.
OPERATION OF VACUUM PAN

Starting pan (batch method)

1—Rinse the pan with hot water.
2—Steam until temperature of 180 F. or above is reached.
3—Close manhole and air valves.
4—Turn water on in condenser.
5—Start water and vacuum pumps.

Operation of pan

1—When 25 inches of vacuum are reached the milk is introduced into the pan by partially opening the milk inlet valve.
2—The milk enters the pan automatically because of reduced pressure.
3—As each coil becomes submerged turn on the steam in that coil.
4—When heating surfaces is fully covered the milk intake is adjusted to synchronize with the rate of evaporation.
5—By the time all the milk is in the pan the condensing is nearly completed. Ten to twenty minutes of further boiling gives proper density.
6—As milk reached higher density it becomes more viscous and boils sluggishly. Reduce steam pressure so as to prevent burning.
Shutting down the pan

1—Shut off steam to coils.

2—Shut off condensing water.

3—Stop the vacuum pump and water pump and open air relief valve.

4—Remove the product from the pan.
DIRECTIONS FOR DEFROSTING HARDENING ROOM

1—Turn off the ammonia on the high pressure line (small line). Leave the suction line (large line) open so that any ammonia in the diffuser can return to the ammonia compressor.

2—After 5 minutes turn off the diffuser fan.

3—Take the stopper out of the water return line.

4—Cap the cold water valve.

5—Turn on the cold water valve.

6—Check in hardening room to see that all connections are in place and that the water is flowing over the diffuser.

7—Allow the water to run over the diffuser until it is defrosted (usually 45-60 minutes are required).

8—When defrosting is completed turn off the water valve and permit the diffuser to drain 5 minutes.

9—Remove the cap from the cold water by-pass line and permit the water to drain completely.

10—Replace the stopper in water return line so that cold air cannot escape through the line.

11—Turn on the fan.

12—Open the valve on the high pressure ammonia line.
The purpose of washing dairy equipment is to remove all milk solids and other material in order to have a clean surface satisfactory for sterilization. The first step in cleaning milk containers is to rinse them with warm water as soon as they have been emptied.

After being rinsed and drained, the equipment should be brushed with a washing solution used at a temperature of about 120 F. It should then again be rinsed with warm water to remove the solution and any loose solid material that may remain.

**Washing Milk Cans**

Mechanical can washers must be operated properly, or they will not accomplish the work. The first important point is the temperatures of the rinse waters, washing solution, and steam. The rinse water should be warm enough to melt and remove any fat that may remain in the can, as well as to rinse the other milk solids from the inner surface. The washing solution should be held at 130 F. and the second rinse water at 190 F. or higher in order that the metal of the can will be heated to a high temperature before the steam is applied.

The steam supplying the jets for steaming the inverted cans in the can washer usually has a pressure of about 60 pounds per square inch. It will then have a temperature of 293 F.
Cleaning and Sterilizing Milk Truck Tanks

1—The manhole is opened and rinsed; the gasket is removed, cleaned, rinsed, and laid aside for later replacing.

2—The inside of the tank is rinsed from the manhole with warm water from a hose. The rinsing should be discarded.

3—The entire inner surface should be brushed and cleaned with cleaning solution. After the washing procedure has been completed, and the material used for cleaning been rinsed off, then the tank is ready for sterilization.

Chlorine sterilizing solutions are best applied by means of spraying equipment. A convenient method is to use a pipe equipped with a nozzle to the manhole and apply the chlorine solution under pressure.

Sterilization of Equipment

In the dairy industry, sterilization as applied to equipment, etc., is a process which destroys for all practical purposes most of the microorganisms (10).

The use of hot water

Hot water may be used for sterilizing dairy utensils if steam is not available. In that case the minimum exposure should be 180 F. for not less than 15 minutes. It is more satisfactory, however, to immerse the equipment in boiling water for not less than 5 minutes, drained the utensils for a brief period, and place them in such a position that they will be kept dry. Another reason for drying is to prevent rusting.
The use of steam

Steam sterilization is most satisfactory to use for a market milk dairy. Steam not under pressure has a temperature of 212 F. When steam is confined in a closed container, pressure develops, and the pressure increases, the temperature of the steam rises. At 5 pounds pressure the temperature is 227 F., and at 15 pounds it is 240 F.

The use of chemicals

Chlorine compounds have a high sanitizing efficiency at low cost when used in proper concentration. Generally speaking, chlorine is used in concentration from 50-300 ppm (part per million) available chlorine. It is not toxic when used in dilute solution.

Hot chlorine solutions may be used to "sanitize" dairy equipments. In a wide range of temperatures from 80-160 F. for time periods up to 2 1/2 hours hot solutions could maintain their initial chlorine content, if no foreign organic matter is present.

Cleaning and Sanitizing the Churn

1—Rinse the butter particles from the churn by spraying with hot water. Permit this water to drain from the churn.

2—Fill the churn about one-fourth full of hot water of about 150-160 F. and one-half pound of dairy detergents. Revolve the churn from 5-10 minutes. Leave the air release valve open a small space so that the pressure
built up inside the churn can escape while the churn is revolving.

3—Rinse the churn again using scalding hot water.

4—Leave the door and the buttermilk valve open so that air can circulate through the churn.

5—If the churn is not used regularly, it should be filled one-fourth full of hot water and revolve for 10 minutes every other day.

Table 5. Strength of chlorine solutions for various applications (18)

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<tr>
<th>Items</th>
<th>Methods of application</th>
<th>Recommended available chlorine (ppm)</th>
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<tr>
<td>Bottles</td>
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<tr>
<td>Vats, tanks, coolers, etc.</td>
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<tr>
<td>Vats, tanks</td>
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</table>
Figure 3. Plan for dairy plant, 10,000 pounds of milk per day
Figure 4. Basement plan
FLOOR PLAN DESCRIPTION AND CAPACITY OF THE EQUIPMENT

A. CIP Tank
B. Can washer 6 cans/minute rotary type
C. Storage tank 12,000 pounds with ref.
D. Pump with flow meter guage
E. Pasteurizing vat 2,000 pounds
F. Separator 2,000 pounds/hour
G. Separator disc washing tank
H. Separator pump 2,000 pounds/hour
I. Pasteurizing vat 2,000 pounds
J. Bottle washer 1,500 glass pints/hour
K. Holding tank 800 gallons no ref.
L. Float tank
M. Homogenizer 3,000 pounds/hour
N. H. T. S. T. 3,000 pounds/hour
O. Storage tank 2,000 pounds no ref.
P. Bottle filler 40 glass pints/minute
Q. Instrument panel
R. Scale for weighing
S. Pipe washing sink
T. Pasteurixing vat 50 gallons
U. Ice cream mix tank 200 gallons, with ref.
V. Pasteurizing vat 100 gallons
W. Ice cream freezer 40-80 gallons/hour
X. Ice cream cup filler Using 40 ounce cups
Y. Cheese vat 1,500 pounds
Z. Cheese press for "Y" 6 feet

1—Anti-hardening room
2—Starter room
3—Ladies toilet
4—Ladies dressing room
5—Ladies lockers
6—Main entrance
7—Lunch room
8—Men's dressing room
9—Men's locker
10—Men's toilet
11—Shower room
12—Receiving room
13—Case and bottle storage room
14 and 15—Elevator
16—Oil storage area
17—Repairs and tools

The area of the plant is 70 by 50 feet.
WHAT IS MANAGEMENT (7, 8)

Management must be defined as the science of adjusting to changes. Change alone would not be a problem if knowledge were perfect. Since knowledge is not always perfect, the principle task of management is to seek new knowledge and correctly interpret it. To do this, management usually must depend on many other people. After getting bits of knowledge, a manager must make the decision for action and he alone must accept the responsibility for that decision. The old cliche, that it is not the work but making the decision that causes ulcers, is truer today than ever before.

Duties and Responsibilities of Production Manager

1—Achieve efficient production and control of all products manufactured.

2—Concern himself with adequate plant procedures, sanitation, layout, maintenance, improvement and product development.

3—Detect operating problems and take corrective measures.

4—Organization in each division.

5—Serve as a "watch dog" over the purchases.

6—Develop programs for the improvement of production methods, processing equipment, and plant.

7—Insure adequate supervision for correct installation layout or purchase of new equipment and facilities.
8—Direct the activities of the organization in the absence of the general manager.

**Plant Location**

The value of the location of a dairy enterprise depends upon a number of factors such as the availability of raw supplies, transportation, sewage-disposal facilities, labor, and nearby market. Because of the cost involved, it is not always possible to make a change in plant location as soon as the need becomes apparent, although in some such cases a change in the product manufactured may be advisable.

Once the general geography of the location has been decided, a suitable town site must be found. The size of the community, and the product to be processed are the more important points to consider in site selection.

**Equipment Maintenance**

Dairy equipment must be maintained in condition for uninterrupted service. Breakdown or delay for repairs may require that the plant cease operations, as many pieces of equipment are dependent upon each other for continuous plant operation.

The responsibility for the maintenance and care of equipment should be definitely assigned. In small plants it usually becomes the duty of the
owner or the superintendent to see that the equipment is kept in proper order. In order to have uninterrupted operation in a plant the equipment should be regularly inspected, lubricated, serviced, and overhauled.

**Replacement**

The maintenance department must be prepared to advise management on equipment replacement. A review of service and repair records will indicate whether or not the unit has given satisfactory performance and for how long. The life of a machine or piece of equipment depends largely upon the factors discussed above.

**Plant Losses**

The control of losses in the dairy involves a three-point approach:

1.—The overall plant loss must be determined. The total input minus the sales, will equal plant loss or shrinkage.

2.—Ascertain where the losses occur.

3.—Establish means to eliminate all the controllable losses possible.

Plant losses occur usually in the following areas:

1.—Inaccurate weight.

2.—Weight losses.

3.—Spillage losses.

4.—Standardization.
Principles of Refrigeration

Extraction of heat from a body at a temperature lower than that of the surroundings, is one of the most important processes in the dairy industry. Refrigeration is accomplished when a cool body is brought near to warmer body, according to the fundamental principle that heat always passes from a warm body to a cooler one, the exchange being capable of continuing until the two bodies are at the same temperature.

Types of Refrigeration

1—Natural refrigeration utilizes ice water, water ice, or ice-and-salt mixtures. Cooling by ice is a very old process; it is effective because, as the ice melts, it takes up great quantities of heat before temperature changes. Each pound of ice in melting will absorb 144 B. T. U. of heat, which is its heat of fusion. British Thermal Unit, (B. T. U.), the quantity of heat required to raise the temperature of one pound of water one Fahrenheit degree.

2—Artificial refrigeration is accomplished principally by the mechanical compression system or the absorption system, both of which have a number of variations. The compression system is by far the most widely used on account of its dependability, ease of control, and simplicity.
The most common refrigerants are ammonia, sulfur dioxide, carbon dioxide, methyl chloride, and freon.
DISCUSSION

Milk from healthy cows is clean and wholesome; once contaminated it can never be restored by any method of processing to its original high standard of purity and quality. Therefore, produce clean milk and keep it clean. There is no better food than milk obtained from clean, healthy cows and handled in a sanitary manner.

The bacterial content of milk and cream should always be kept as low as possible. If present in considerable numbers in milk or cream and the temperature of their growth satisfactory, the bacteria may seriously affect the flavor of the product and may produce enough acid to coagulate the casein. The market value of the product may be considerably lowered.

It is fundamental to know where the bacteria occurring in milk or cream come from in order that they may be controlled. It is of importance to have a program of keeping the bacteria out of milk and cream than it is to devise means for destroying them when present in these products. There is no known process that may be used for removing the flavor compounds formed by bacterial action in milk and cream and restoring the lost quality.

The economic importance of the ice cream has been established. The value of ice cream as a food is now realized and much scientific knowledge has been gained in the production and merchandizing of ice cream. Further technology and advancement may be expected to accelerate the demand for ice cream.
Bacteriophage could be the cause of very considerable loss to the processing plant. Nothing now known indicates that causes of slow acid production will be eliminated soon. Therefore, the well-operated plant must make sure that both producer and plant employees know what must be done to minimize trouble from these undesirable agents.

Antibiotics have not been very likely the magical remedy for all health problems of the dairy herds. Good management practices that will keep the herd clean and healthy along with good milking practices should reduce the quantity of antibiotics it is necessary to use. A thorough understanding of these facts should make it less necessary to feed and treat with antibiotics.

Accidental modifications or changes in one or more steps of the cheese-making process throughout the centuries were largely responsible for the development of the different kinds of cheese. These changes were little understood and difficult to duplicate because scientific knowledge of bacteriology and chemistry was lacking. As a result, cheesemaking was considered an art, and the making process was a closely guarded secret passed from father to son. With increased scientific knowledge, especially since 1900, has come an understanding of the bacteriology and chemistry involved in the making of many cheeses. Thus it has become possible each step in the making process and to manufacture a uniform product. Now, cheesemaking is a science rather than an art.

No cheese factory can afford to use starters that are inactive and that are contaminated with bacteriophage or foreign bacteria; new starter cultures should be secured regularly from reliable laboratory.
BIBLIOGRAPHY


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<td>August, 1964</td>
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<td>Morris, A. J.</td>
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<td>Nelson, F. E.</td>
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APPENDIX
Table 6. Weight of milk in different capacities

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Serum Point Method for Figuring Ice Cream Mixes (1)

Pounds of serum solids concentrate = 0.09 X Pounds of mix serum

Fraction of milk-solids-not-fat in the mix

Fraction of serum solids-not-fat in the serum solids concentrate.

Definitions

Fraction. — Per cent when figuring on a 100 pounds basis.

Serum-solids. — Milk-solids-not-fat, or S.S. = MSNF.

Mix serum. — 100 - pounds fat + sugar + CSS + stabilizer + emulsifier.

C.S.S. — Corn syrup solid.
Weights and Measures (7, 8)

1 Liter = 1000 ml.

1 Gallon = 3785 ml.

1 Gallon = 3.785 liters

1 Fluid ounce = 29.57 ml.

1 Gallon water at 59 F. = 8.337 pounds

1 Gallon milk at 60 F. = 8.59 pounds

1 Quart milk at 60 F. = 2.15 pounds

4 Quarts milk at 60 F. = 1 gallon

1 Gallon skim milk at 60 F. = 8.64 pounds

1 Gallon 20 per cent cream = 8.48 pounds

1 Gallon 30 per cent cream = 8.39 pounds

1 Gallon 40 per cent cream = 8.32 pounds

Specific gravity of milk = 1.032

Specific gravity of skim milk = 1.036

Specific gravity of 30 per cent cream = 1.006

Specific gravity of 40 per cent cream = 0.999

Specific gravity of butterfat at 60 F. = 0.93

Specific gravity of butterfat at 135 F. = 0.90

1 Pound = 453.6 grams

1 Ounce = 28.35 grams

1 Pint of milk = 1 pound

32 Ounces = 1 quart
30 CC = 1 ounce
L. cc = 1 ml.
1 Gallon of chocolate drink = 8.8 pounds
1 Quart of chocolate drink = 2.2 pounds
1 Pint of chocolate drink = 1.10 pounds
1 Half-pint of chocolate drink = 0.5 pounds
1 Gallon of ice cream mix = 9.2 pounds.
1 Gallon of ice milk mix = 9.30 pounds
1 Gallon of sherbet mix = 9.55 pounds
Fat test in butter = 80.50 per cent
1 Meter = 39.37 inches
1 Meter = 1.093611 yards
1 Meter = 3.280833 feet
1 Kilometer = 3,281 feet
1 Liter = 1.0567 quarts
1 HP = 746 watts
1 Pound psi = 2.309 feet of water at 62 F.
Table 8. Effect of temperature on weight of milk\textsuperscript{a}

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\textsuperscript{a}Milk Industry Foundation Bulletin, No. 10, March 11, 1947, p. 257.

Table 9. Comparison of thermometer readings (7, 8, 17)

<table>
<thead>
<tr>
<th>Cent.</th>
<th>Fahr.</th>
<th>Cent.</th>
<th>Fahr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20</td>
<td>-4.0</td>
<td>45</td>
<td>113.0</td>
</tr>
<tr>
<td>-18</td>
<td>-0.4</td>
<td>49</td>
<td>120.2</td>
</tr>
<tr>
<td>-16</td>
<td>+3.2</td>
<td>50</td>
<td>122.0</td>
</tr>
<tr>
<td>-14</td>
<td>6.8</td>
<td>55</td>
<td>131.0</td>
</tr>
<tr>
<td>-10</td>
<td>14.0</td>
<td>57</td>
<td>134.0</td>
</tr>
<tr>
<td>0</td>
<td>32.0</td>
<td>58</td>
<td>136.4</td>
</tr>
<tr>
<td>+1</td>
<td>33.8</td>
<td>60</td>
<td>140.0</td>
</tr>
<tr>
<td>5</td>
<td>41.0</td>
<td>62</td>
<td>143.6</td>
</tr>
<tr>
<td>10</td>
<td>50.0</td>
<td>65</td>
<td>149.0</td>
</tr>
<tr>
<td>15</td>
<td>59.0</td>
<td>72</td>
<td>161.6</td>
</tr>
<tr>
<td>20</td>
<td>68.0</td>
<td>73</td>
<td>163.4</td>
</tr>
<tr>
<td>22</td>
<td>71.6</td>
<td>74</td>
<td>165.2</td>
</tr>
<tr>
<td>23</td>
<td>73.4</td>
<td>80</td>
<td>176.0</td>
</tr>
<tr>
<td>25</td>
<td>77.0</td>
<td>85</td>
<td>185.0</td>
</tr>
<tr>
<td>30</td>
<td>86.0</td>
<td>88</td>
<td>190.4</td>
</tr>
<tr>
<td>35</td>
<td>95.0</td>
<td>90</td>
<td>194.0</td>
</tr>
<tr>
<td>39</td>
<td>102.2</td>
<td>95</td>
<td>203.0</td>
</tr>
<tr>
<td>40</td>
<td>104.0</td>
<td>100</td>
<td>212.0</td>
</tr>
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</table>
Table 10. Autoclave steam pressures and corresponding temperatures (17)

<table>
<thead>
<tr>
<th>Steam pressure 1 pound/square inch</th>
<th>Temperature C</th>
<th>Temperature F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100.0</td>
<td>212.0</td>
</tr>
<tr>
<td>1</td>
<td>101.9</td>
<td>215.4</td>
</tr>
<tr>
<td>2</td>
<td>103.6</td>
<td>218.5</td>
</tr>
<tr>
<td>3</td>
<td>105.3</td>
<td>221.5</td>
</tr>
<tr>
<td>4</td>
<td>106.9</td>
<td>224.4</td>
</tr>
<tr>
<td>5</td>
<td>108.4</td>
<td>227.1</td>
</tr>
<tr>
<td>6</td>
<td>109.8</td>
<td>229.6</td>
</tr>
<tr>
<td>7</td>
<td>111.3</td>
<td>232.3</td>
</tr>
<tr>
<td>8</td>
<td>112.6</td>
<td>234.7</td>
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<td>113.9</td>
<td>237.0</td>
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<td>115.2</td>
<td>239.4</td>
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<td>116.4</td>
<td>241.5</td>
</tr>
<tr>
<td>12</td>
<td>117.6</td>
<td>243.7</td>
</tr>
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<td>13</td>
<td>118.8</td>
<td>245.8</td>
</tr>
<tr>
<td>14</td>
<td>119.9</td>
<td>247.8</td>
</tr>
<tr>
<td>15</td>
<td>121.0</td>
<td>249.8</td>
</tr>
<tr>
<td>16</td>
<td>122.0</td>
<td>251.6</td>
</tr>
<tr>
<td>17</td>
<td>123.0</td>
<td>253.4</td>
</tr>
<tr>
<td>18</td>
<td>124.1</td>
<td>255.4</td>
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<tr>
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<td>258.5</td>
</tr>
<tr>
<td>25</td>
<td>130.4</td>
<td>266.7</td>
</tr>
<tr>
<td>30</td>
<td>134.5</td>
<td>274.1</td>
</tr>
</tbody>
</table>
Standardization of Milk and Cream (16)

"Standardization" of milk and cream refers to the adjustment of the fat percentages to a definite value. Calculations for standardization are generally simplified by the use of the Pearson Square Method. The square operates as follows:

<table>
<thead>
<tr>
<th>PER CENT FAT OF CREAM TO BE (A)</th>
<th>DIFFERENCE BETWEEN (B) AND (C);</th>
<th>THIS REPRESENTS PROPORTION OF (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARDIZED (A) (D)</td>
<td>(C) PER CENT FAT</td>
<td>DESIRED</td>
</tr>
<tr>
<td>PER CENT FAT OF MILK TO STANDARDIZE WITH (B) (E)</td>
<td>DIFFERENCE BETWEEN (A) AND (C);</td>
<td>THIS REPRESENTS PROPORTION OF (B)</td>
</tr>
</tbody>
</table>

Example 1

800 pounds of 41.5 per cent cream must be reduced to 35 per cent cream by the use of skimmilk testing 0.05 per cent fat. How much skimmilk must be added.

Solution 1: 800 X 0.415 = 332.00 pounds fat in 800 pounds of cream.

\[
332.00 \times \frac{100}{35} = 948.57 \text{ or } 948.5 \text{ pounds cream testing } 35 \text{ per cent.}
\]

\[
948.5 - 800 = 148.5 \text{ pounds skimmilk required.}
\]
Solution 2:

The ratio of 34.95: 6.5 = 800; X

$\frac{6.5}{34.95} = \frac{X}{800} = 148.78$

$X = 148.78$ pounds of skim milk must be added to 800 pounds of cream.

Example 2

2000 pounds of 32 per cent cream are wanted. 38 per cent cream and skim milk testing 0.1 per cent fat are available. How many pounds of 38 per cent cream and of skim milk are needed.

Solution 1: $2000 \times 0.32 = 640.00$ pounds of fat needed.

$\frac{640.00 \times 100}{38} = 1684.0$ pounds of 38 per cent cream required.

$2000 - 1684 = 316.0$ pounds of 0.1 per cent skim milk required.

Solution 2:

The ratio of $\frac{6.0}{37.9} = \frac{316.6}{2000}$ pounds of 0.1 per cent skim milk required.

$2000 - 316.6 = 1683.4$ pounds of 38 per cent cream required.