Station Bulletin 379 December 1940

PREPARATION OF STARTER FOR
CHEESE · BUTTERMILK · BUTTER

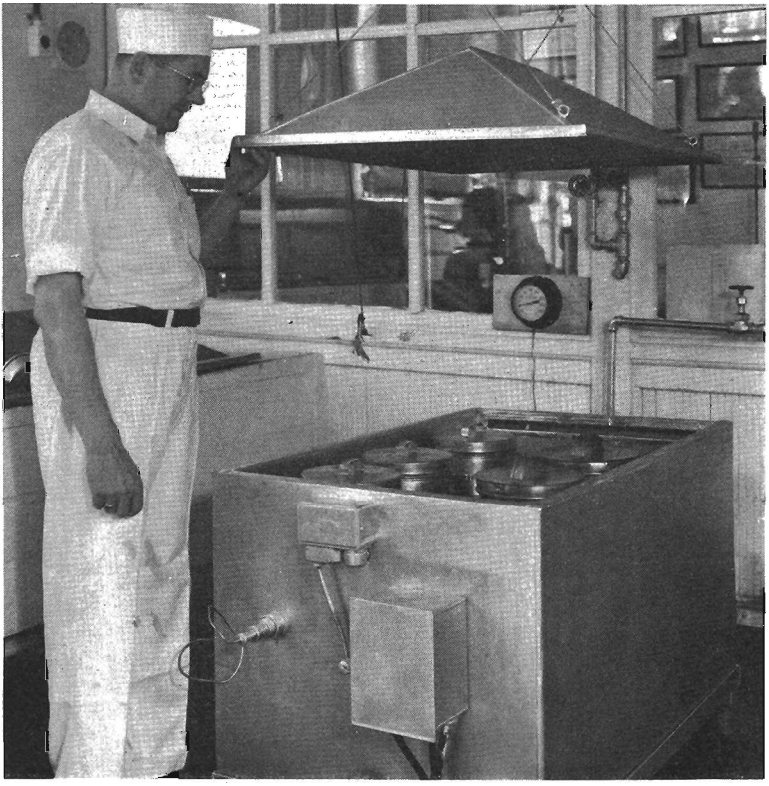

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Illustration on cover—

Combined pasteurizer, cooler, and incubator for large batches of starter. Five-gallon cans constructed from stainless steel used. Steam used for heating. Note electric insert heater near bottom and electric thermostat near top of tank used during incubation.

FOREWORD

PRIOR to 1932 the chief obstacle in the preparation of starter in Oregon dairy plants was the lack of simple and inexpensive equipment for preparing and carrying cultures. The necessary equipment was designed by the Oregon Agricultural Experiment Station in 1932.

Some simplification and refinement have been effected in the original equipment. After a period of three years experience in using the modified equipment for the preparation of starter in the Experiment Station Dairy Products Laboratory it is possible to give to Oregon Dairy Plants a detailed outline of the most desirable method of preparing starter.

By using the method suggested, it should be possible for dairy plants to prepare a high and uniform quality starter day by day. This should be reflected in greater market returns.

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Preparation of Starter for Cheese, Cultured Buttermilk, and Butter

By

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F. E. PRICE, Professor of Agricultural Engineering.*

STARTER is indispensable in the manufacture of Cheddar and cottage cheese and for certain miscellaneous types of cheese made in Oregon. It is also necessary in the manufacture of cultured buttermilk. Although it is not absolutely essential in the manufacture of butter, a number of Oregon creameries use small amounts of starter regularly for butter. From an economic and marketing point of view, it is of great importance that the manufacturing plants follow a definite procedure in preparing the milk culture known as starter in order that it may contain the desirable types of bacteria regularly from day to day. If low quality starter is used, serious damage may be done to the final product. In some instances, the starter obtained may be of such low quality that it cannot be used at all.

About 125 milk products plants in Oregon use starter in the manufacture of different dairy products. The amount of starter used in these plants aggregates approximately 11,000 to 12,000 pounds per day or somewhat more than 4,000,000 pounds per year.

The value of Oregon dairy products with which starter is used is approximately $6,000,000 per year. It is because of the realization of the importance of the manufacture of high and uniform quality of dairy products for sale within the state of Oregon and for out-of-state markets that the Experiment Station has given considerable attention to the manufacture of starter that contains the most desirable bacteria and has the qualities requisite for a high quality product.

About 75 per cent of the starter made in Oregon is used in the manufacture of cheese.

REASONS FOR USING STARTER

A. For Cheddar cheese

1. To favor the coagulation by rennet† of the casein in milk, known as calcium caseinate, to give calcium paracaseinate. The acid produced from the activity of the bacteria also activates the pepsin of the rennet extract. A certain amount of soluble calcium salt (monocalcium phosphate $CaH_4(PO_4)_2$) is also formed through the action of the acid on the dicalcium phosphate in the milk. This first-named salt is necessary for the coagulation of the casein by the rennet enzyme.
2. To aid, through the acid produced, the expulsion of moisture from the curd particles.
3. To aid, through the action of the acid, the formation of brine-soluble calcium paracaseinate from the insoluble calcium paracaseinate during

* The authors appreciate the courtesy of Dr. B. W. Hammer of Iowa State College in reviewing the manuscript, and thank him for suggestions made.

† Rennet contains the enzyme chymase (or chymosin) commonly known as rennase or rennin. The enzyme pepsin is also present.

the cheddaring process so the curd particles will mat together and the cheese will have a compact texture.

4. To check, by the acid produced, the growth of undesirable types of bacteria in the curd during manufacture and in the cheese during ripening.

During the first several weeks of the ripening process, good cheese contains approximately 99.9 per cent of the types of bacteria that are present in starter. Many millions of bacteria are present per gram of cheese.

B. For cultured buttermilk

1. To give a desirable flavor.
2. To produce a desirable body.
3. To produce the necessary acidity.
4. To check the growth of undesirable bacteria.

Note: Other types of fermented milk are (1) Bulgarian milk, which contains the bacterium *Lactobacillus bulgaricus*, and (2) Acidophilus milk, which contains the bacterium *Lactobacillus acidophilus*.

C. For cottage cheese

1. To coagulate the casein so a curd is formed. (Colloidal calcium caseinate is changed to free casein through removal by the acid of calcium from the calcium caseinate).
2. To produce flavor.
3. To aid, through the action of the acid, the expulsion of moisture from the curd particles during "cooking."
4. To preserve the cheese through the prevention of the growth of putrefactive types of bacteria.

D. For butter

1. To impart a more desirable flavor to the butter.
2. To prevent the development of certain undesirable types of bacteria in the butter, particularly in unsalted butter.
3. To make less pronounced certain undesirable flavors such as feed, tallowy, neutralizer, and scorched flavors.
4. To aid in making butter of a more uniform quality.

There is some difference of opinion regarding the advantages of using starter in the manufacture of butter. At present only about 20 per cent of Oregon's butter is made with starter. Most of this butter is consumed in the state. It is not the purpose here to enter into a discussion of the merits or demerits of using starter in butter. The individual creameries should decide whether, from a marketing point of view, starter is beneficial in the manufacture of butter.

STEPS IN THE PREPARATION OF STARTER

It is possible to prepare good quality starter day by day. It is necessary, however, to use fine-quality milk and to observe certain fundamental rules for the preparation. The milk should be placed in a sanitary container, preferably glass or stainless steel, and all parts of the milk as well as the container should be subjected to pasteurization, followed by cooling to the correct temperature for inoculation of the milk, and avoiding contamination of the milk with un-

desirable types of micro-organisms. The inoculated milk should be kept at a suitable temperature for the growth of bacteria in the milk. The final stage consists of examining the coagulated milk and cooling it to a low temperature to retard further growth of the bacteria.

Although it may be possible during a limited period to make satisfactory starter when using makeshift equipment, dependable results can be obtained only if specifically constructed equipment is used.

BACTERIA PRESENT IN STARTER

The bacteria present in starter are of the lactose (milk sugar) and citric-acid fermenting types.

Streptococcus lactis ferments lactose, of which there is nearly 5 per cent in average milk, to lactic acid ($CH_3 \cdot CH(OH) \cdot COOH$). About one-fifth of the lactose is converted to lactic acid with a maximum acidity in the fermented milk of 0.9 to 1.0 per cent. In starter, a strain of this type of organism that produces acid rapidly is desirable. Certain cultures of this species of organism may produce an undesirable flavor, such as a malty flavor or even a feed flavor. The most desirable cultures produce very little or no flavor, but simply produce lactic acid, which is odorless, from milk sugar. *Streptococcus lactis* is responsible, therefore, for the production of acid flavor (taste).

The citric-acid fermenting bacteria that are always present in fine-quality starter are either *Leuconostoc citrovorus* or *Leuconostoc dextranicus*. The organisms grow associatively with *Streptococcus lactis*. They produce citric acid

$$\begin{array}{l} CH_2 \cdot COOH \\ | \\ C(OH) \cdot COOH \\ | \\ CH_2 \cdot COOH \end{array}$$

of which there is nearly 0.2 per cent in average milk, acetylmethylcarbinol ($CH_3 \cdot CH(OH) \cdot CO \cdot CH_3$), diacetyl ($CH_3 \cdot CO \cdot CO \cdot CH_3$), and 2, 3-butylene glycol ($CH_3 \cdot CH(OH) \cdot CH(OH) \cdot CH_3$). The formation of acetylmethylcarbinol takes place after a considerable amount of acid has been produced by the *Streptococcus lactis* organisms. Acetic acid and carbon dioxide are also formed.

The compounds acetylmethylcarbinol and diacetyl are responsible for the desirable flavor of good starter. Acetylmethylcarbinol in a pure form is odorless. A portion of that produced oxidizes in starter (favored by aeration under a pressure of about 30 pounds per square inch) to diacetyl, which has a very desirable aroma. The addition of citric acid to the pasteurized milk before inoculation increases the amount of acetylmethylcarbinol and diacetyl produced. In dilute form diacetyl has an odor resembling that of good butter. But 2, 3-butylene glycol has no odor. Different mixtures of the lactose and citric-acid fermenting bacteria show variations in the production of acetylmethylcarbinol and subsequently diacetyl. The conditions for growth of the bacteria in the milk and the amount of acid produced also affect the amount of diacetyl obtained. When used for butter, the addition of citric acid before inoculation of the milk is advantageous in that a more uniform and more highly flavored starter is obtained and less starter can be used with the cream.

General characteristics of the bacteria in starter are given on page 21. It is not within the scope of this bulletin to discuss in detail the bacteriology of

starter. Dr. B. W. Hammer and his associates at the Iowa Agricultural Experiment Station, Ames, Iowa, have studied the chemical and bacteriological aspects of starter in detail. They have published a considerable number of reports on their findings.

COMMERCIAL CULTURES

Starter culture can be obtained in either liquid or dry form from a number of laboratories. Liquid culture contains the bacteria in an active form when shipped from the laboratory. It is important to use the culture for inoculation as soon as possible after it has been received. It is advisable to place the culture in the refrigerator immediately upon receipt. During the summer months shipment of the culture by airplane is best.

The powder cultures contain the bacteria in a dormant form. Although many millions are present per gram, the organisms are inactive and for this reason they do not develop rapidly in the milk during the first or second incubation periods.

Care should be taken to pass the mouth of the bottle containing the commercial culture through an open flame immediately before inoculation.

PREPARATION OF MOTHER STARTER

(Method developed and used at Oregon Agricultural Experiment Station.)

Glass jars are filled about three-fourths full with milk. The glass lids are held in place on each jar by means of a metal clamp, but no rubber gasket is used. The jars are placed in a tank with water reaching above the level of the milk in the jars, this being regulated by means of an overflow pipe.

The best quality whole milk obtainable should be used. The milk from a farm that regularly produces milk containing a small number of bacteria should be selected. The milk should not only contain a minimum number of bacteria, not more than 10,000 per cc, and preferably only 1,000 or 2,000 per cc, but it should have a desirable flavor. A check should be made periodically on the number of bacteria present. The methylene blue reduction fermentation test may be used to determine the numbers and types of bacteria present. A more refined test is, of course, the agar plate method. It is advisable to use the mixed milk from several cows. It is best to obtain the milk as quickly after milking as possible and pasteurize it as soon as it is received at the plant.

1. **Apparatus and glassware to use for the preparation of mother starter.**

(1) Half-gallon fruit jars fitted with glass lids and metal clamps, but without rubber gaskets.
(2) A specially designed combined pasteurizer, cooler, and incubator.
(3) A simple pipette sterilizer.
(4) A supply of graduated glass pipettes or tubes.
(5) A small tank for cooling and storing jars of starter in ice water.

2. **Pasteurizing the milk.** The pasteurizing tank is made of copper with a brass ½-inch pipe steam-heating coil in the bottom.* If brass is not available,

* Designed in 1932. Price, F. E., Wilster, G. H., and Hurd, C. J., Design of Equipment and Method of Preparing Starter for Oregon Creameries and Cheese Factories. Oregon Exp. Sta. Bul. 301, 1932.

a copper coil may be used in preference to galvanized iron. A steam trap is connected to the end of this coil so that all noise and escaping steam during heating is eliminated. The condensed steam is conducted directly to the sewer. A tank of this type has been used daily in the Dairy Products Laboratory since 1932 and has been found very satisfactory.

In the operation of the pasteurizer, the lid on the tank is kept closed during the heating process so as to confine heat in the part of the tank that is above the water level, and to prevent the escape of steam into the room.

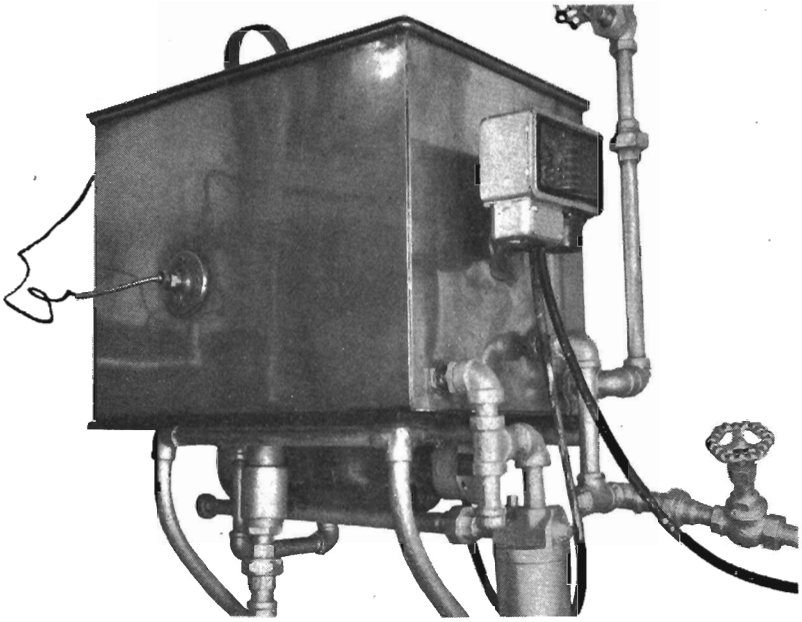

Figure 1. The combined pasteurizer, cooler, and incubator. Note the electric thermostat and heater. The heater is in direct contact with the water in the tank. An alternate method would be to build the tank slightly deeper and insert the heater above the bottom of the tank.

When steam is not available the water in the tank may be heated to the correct temperature by means of an electric heater.

The jars of milk rest on a rack placed above the heating coils. The milk is pasteurized by gradually heating the water surrounding the jars to about 200° F. in about 40 to 60 minutes. A recording thermometer records the temperature of the water. A simple but accurate indicating angle thermometer may be used. A temperature of about 200° F. is maintained for not less than 1 hour. The lid to the tank must be kept closed during the pasteurizing period.

3. **Cooling the pasteurized milk.** When the tank is used for cooling, cold water is admitted through a ½-inch brass or copper pipe which is placed near the bottom of the tank and which extends to the opposite end of the tank and then up to the water level, where it is divided and released through ⅛-inch holes

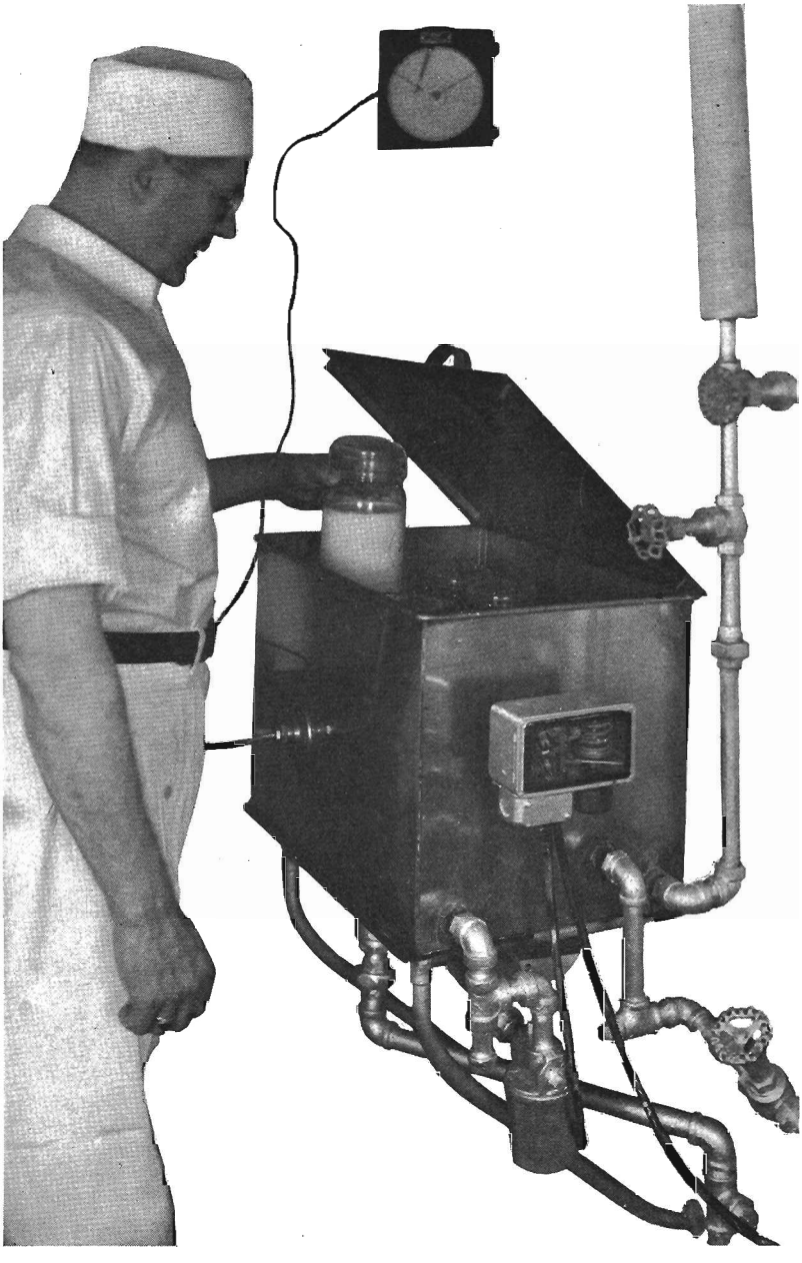

Figure 2. Placing jars of milk in the water bath for pasteurizing.

in three pipes that extend back through the length of the tank. The height of the overflow pipe is arranged so that the three horizontal pipes are nearly submerged. It is important to have the holes on the top side of the pipes. This arrangement makes it apparent to the operator how much cooling water is being admitted by observing the flow of water through the $\frac{1}{8}$-inch outlet holes. By the time the cooling water is released, it is very nearly the temperature of the water in the tank, because it flows through at least 3 feet of pipe that is submerged in the water in the tank. This gradual reduction in the temperature of the water greatly minimizes the danger of breaking the jars. It has been found convenient to allow the cold water to flow through the tank until about $\frac{1}{2}$ to 1 hour before the milk is to be inoculated.

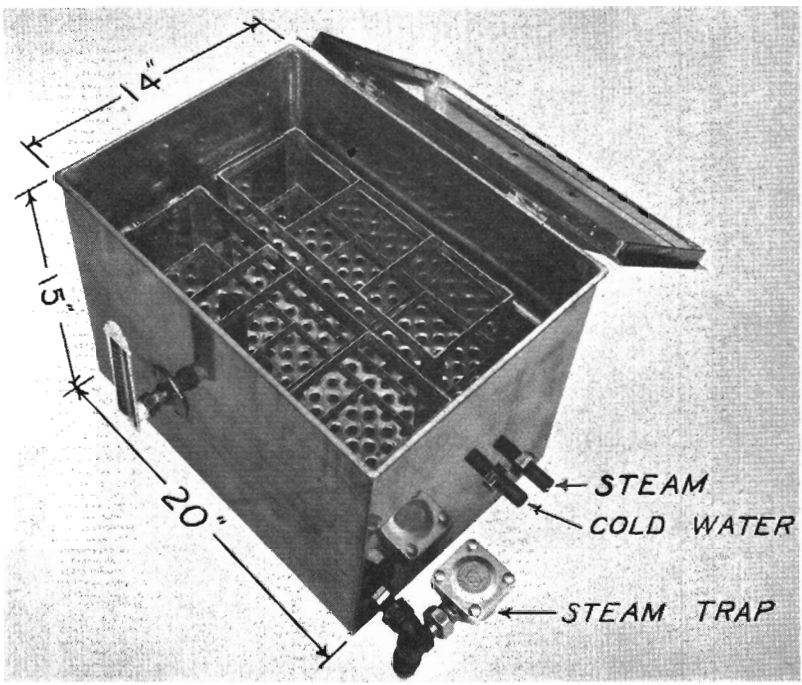

Figure 3. Interior view of the pasteurizing tank. The steam coils are below the removable false bottom. The electric heater used during incubation is located in the bottom of the tank. Note the perforated cooling coil and the overflow pipe.

The next step is adjusting the temperature of the water in the tank to 70° F., which in turn regulates the temperature of the milk. Do not insert a thermometer in the milk on account of the danger of contaminating the milk with undesirable bacteria. The milk is held at 70° F. during incubation. An electric heater with a thermostatic control is provided for this purpose. This heater should be turned on from $\frac{1}{2}$ to 1 hour, depending on the temperature of the water, before the milk is to be inoculated.

4. **Sterilization of the pipettes.** The glass pipettes or tubes should be sterilized before they are used. This is a very important procedure. Unsterile pipettes may add undesirable bacteria to the milk. The pipettes are best sterilized in a small simple steam sterilizer. Such a sterilizer was designed at the Oregon

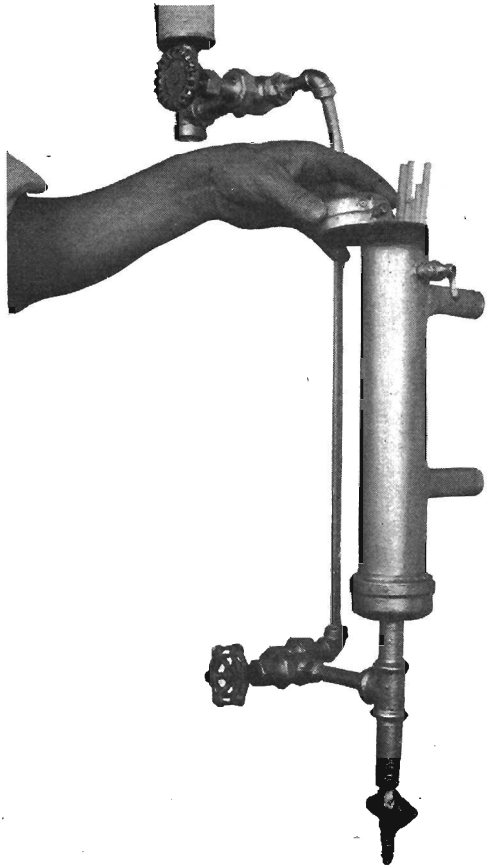

Figure 4. The pipette sterilizer.

Agricultural Experiment Station in 1932. The original sterilizer as installed in the Dairy Products Laboratory at the College has been in use daily and is still giving complete satisfaction. This sterilizer is shown in Figure 4. The apparatus is used not only for sterilizing but also as a container for the clean pipettes or tubes after they have been used. The method used for sterilization consists of exposing the pipettes or tubes to steam under high pressure for a period of from 5 to 10 minutes.

5. **Inoculation of the milk.** The starter culture should be obtained from a reliable source. It is desirable always to carry two different cultures. Fresh ones should be obtained once a month.

The previous batch of mother starter, which was removed from the incubator several hours earlier and kept cold, is used for inoculating the pasteurized, cooled milk. A sterilized pipette is plunged through the cream layer and is filled with starter. The required amount, from 2 to 3 cc per pint of milk, is then allowed to flow from the pipette into the milk. Care should be taken that

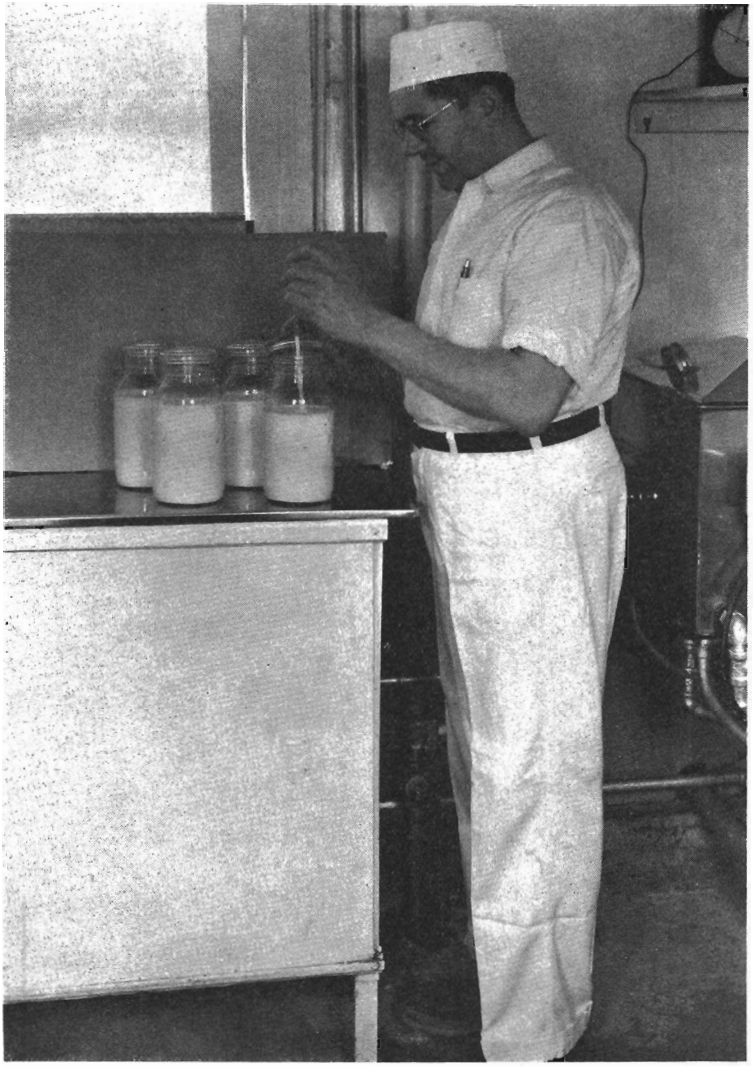

Figure 5. Showing proper method of inoculating the pasteurized and cooled milk.

this operation is done quickly so as not to contaminate the milk or the starter with bacteria from the air. The glass cover on the jar need be lifted only enough to permit inserting the pipette (Figure 5). The jar of inoculated milk is then given a rotary motion so as to mix the milk and inoculum, care being taken that the milk does not splash onto the top edge of the jar under the lid. The inoculated jars are then returned to the water bath in the combined pasteurizer, cooler, and incubator.

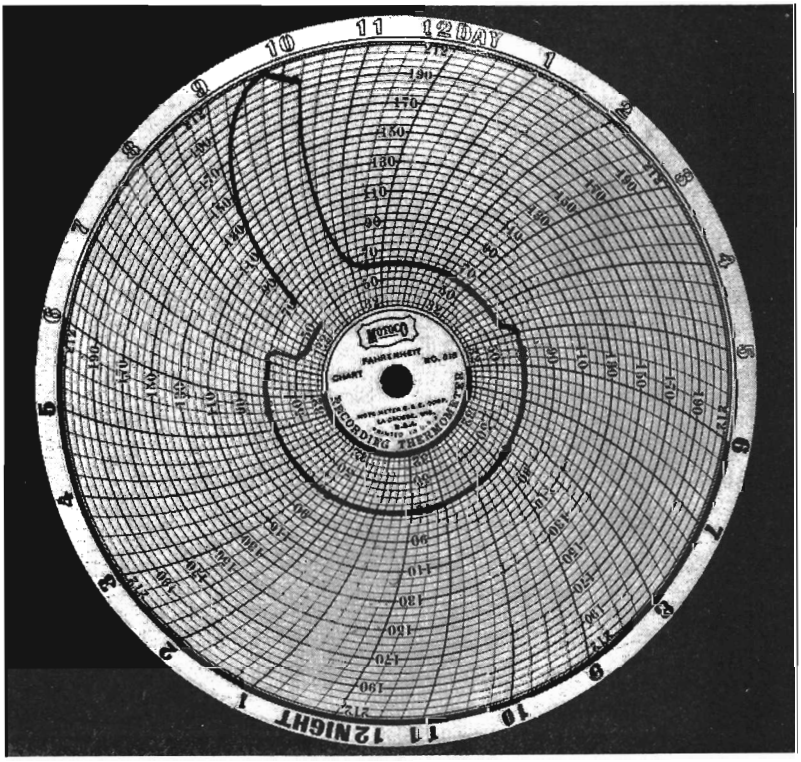

Figure 6. A record of the temperature and time for heating, cooling, and incubating. The milk was held at the incubation temperature for 14¼ hours.

6. **Incubation.** A water-jacketed incubator was one of the units of the equipment that was designed in 1932. By installing an electric heater* in the bottom of the pasteurizing tank and by connecting this heater with a thermostat, it is possible to maintain a temperature of the water in the tank that is suitable for incubation. This eliminates the incubator previously designed. The change makes use of the water bath to serve the three necessary functions in the preparation of starter; namely, (1) pasteurization, (2) cooling, and (3)

* 750 watts insert heater.

incubation. The apparatus is shown in Figure 1 and the details of its construction are shown in Figure 3.*

A combined pasteurizer, cooler, and incubator has been used daily in the Dairy Products Laboratory for 3 years. It has been found entirely satisfactory

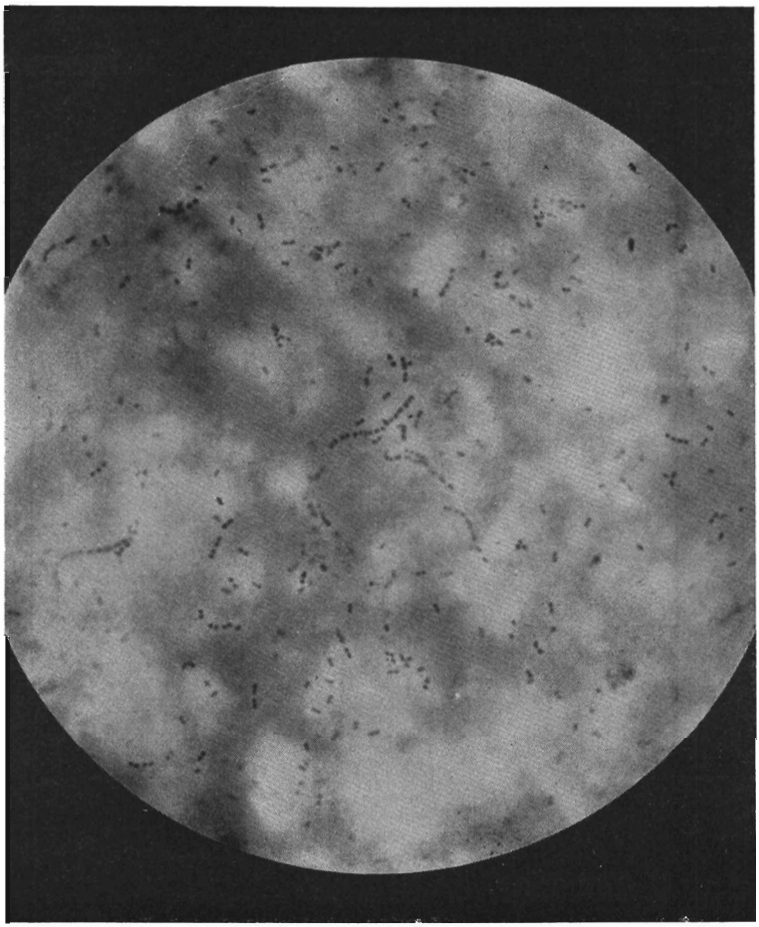

Figure 7. Photograph of bacteria in starter as seen by means of microscope.

and it is believed that it will fill a need in Oregon dairy plants for a relatively inexpensive, compact, easily operated, and efficient piece of equipment for the preparation of mother starter.

* The authors acknowledge the assistance by C. G. Wiltshire, Superintendent of the College plumbing and steamfitting department, in designing and constructing the original and improved equipment.

Incubation consists of keeping the inoculated milk at a temperature of 70° F. during about 14 to 16 hours. The thermostat regulates the temperature of the water in the tank to within 2 degrees of that desired during incubation.

When the temperature of the room in which the tank is kept during the incubation period exceeds the incubation temperature, as during the summer season, it has been found necessary to allow a small amount of cold water (regulated by means of a needle valve) to flow through the cooling coils in order to keep the temperature of the water in the tank from increasing excessively. The electric heater and thermostat automatically maintain the desired temperature. It is always desirable to place the apparatus in a cool part of the building. Insulation of the tank is necessary only when cold water for flowing through the coils is not available.

Figure 8. Mother starter cooled to below 40° F. in ice water.

Table 1. ACIDITY OF STARTER
(Calculated as lactic acid)

Starter number or identification	June 5		June 6		June 7		June 8		June 10		June 11		June 12	
	After 16 hours incubation at 70° F.	After additional 8 hours at 33° F.	After 14 hours incubation at 70° F.	After additional 10 hours at 33° F.	After 16 hours incubation at 70° F.	After additional 8 hours at 33° F.	After 16 hours incubation at 70° F.	After additional 8 hours at 33° F.	After 15 hours incubation at 72° F	After additional 9 hours at 33° F.	After 16½ hours incubation at 72° F.	After additional 7½ hours at 33° F.	After 15 hours incubation at 72° F.	After additional 9 hours at 33° F.
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
100	0.81	0.84	0.77	0.82	0.81	0.83	0.82	0.83	0.77	0.78	0.83	0.85	0.82	0.86
101	.81	.83	.77	.78	.81	.82	.80	.80	.75	.76	.83	.85	.81	.85
H.P.* old culture....	.80	.84	.77	.80	.80	.84	.80	.81	.75	.78	.82	.86	.82	.85
H.P.* new culture....	.....	.....	.72	.75	.78	.82	.80	.82	.74	.78	.82	.86	.81	.84

* Received from Dr. B. W. Hammer, Iowa State College.

7. **Acidity of the starter.** The acidity of the starter after a 14- to 16-hour incubation period at 70° F. generally ranges from 0.75 to 0.80 per cent. This is shown in Table 1. After holding the starter in the glass jars surrounded with ice water for an additional period of 8 to 10 hours the acidity increases slightly, usually up to 0.05 in the percentage, giving an average final acidity before it is used for the following inoculation of from 0.80 to 0.85 per cent.

8. **Cooling the starter.** At the end of the incubation period, after the milk has been firmly coagulated, the jars of starter should be cooled by means of cold, flowing water. Shaking or stirring the starter at this time is unnecessary and is undesirable because of the danger of contamination. Water is allowed to flow through the tank for a period of 1 hour. The water should then be shut off and crushed ice added in order to reduce the temperature of the water to nearly 32° F., or cold brine may be allowed to pass through a coil placed in the tank in order to cool the water in the tank. Another method is to remove the jars of starter to a small insulated tank for cooling and storing in ice water. This quick cooling and storing at a low temperature is necessary in order to prevent the development of an excessive acidity and an undesirable flavor in the mother starter.

SUMMARY OF THE METHOD OF PREPARING MOTHER STARTER

1. Obtain the mixed milk from a herd of cows. Use milk from the morning milking if the milk is to be pasteurized during the forenoon.
2. Use milk of fine flavor.
3. Use milk containing a minimum number of bacteria (not more than 10,000 per cc).
4. Pasteurize the milk in clean glass jars by heating to 200° F. and holding at this temperature for 1 hour.
5. Cool the pasteurized milk to the incubation temperature (70° F.).
6. Use sterilized glass pipettes or transfer tubes.
7. Obtain a culture of bacteria from a reliable source.
8. Use an amount for inoculation that will result in a firm coagulation during a 14- to 16-hour incubation period.
9. Incubate the inoculated milk at a temperature of 70° F.
10. The starter at the end of the incubation period should have an acidity of from 0.75 to 0.80 per cent.
11. Quickly cool the coagulated milk, without stirring, to a temperature of below 40° F.
12. Maintain a temperature of between 32° and 40° F. until the starter is to be used for the inoculation of the next batch of milk for mother starter and for the inoculation of the large batch of pasteurized milk.

THE PREPARATION OF THE LARGE BATCH OF STARTER

1. **Equipment.** A specially constructed pasteurizer equipped with a mechanical agitator may be used. The inside lining and the agitator should preferably be constructed from stainless steel. Some plants prefer to use a tank with water as the heating and cooling medium and cylindrical straight-sided 5- or 10-gallon cans fitted with covers for the milk. With the latter may be used a stirrer inserted through the lid and operated by hand.

It is desirable to have the temperature of the water in the jacket of the pasteurizer and of the water in the tank automatically controlled during the incubation period by means of a thermostat and an electric heater. Thermometers should be used to indicate the temperature of the milk and the temperature of the water. Insulation of the outer wall and bottom of the tank is recommended.

2. **Milk.** Whole or skimmed milk of low bacterial content that has a good flavor should be used. Milk from the morning milking is preferable, if the milk is to be pasteurized during the forenoon.

3. **Pasteurization and cooling.** Pasteurize the milk by heating it to a temperature of 180° to 190° F. and holding it at this temperature with lids closed for 30 to 40 minutes. Cool to 70° F. or, if the milk is not to be inoculated for some time, cool it to 50° F. or lower.

4. **Inoculation.** Adjust the temperature of milk and the water in the jacket of the tank to 70° F. Add approximately 1 pint of mother starter for each 10 gallons of milk, while stirring thoroughly.

If it is desired to make starter that has a more pronounced flavor, as for cultured buttermilk or for butter, a citric-acid solution may be added to the pasteurized and cooled milk. Citric acid may be added to the milk at the rate of 0.15 per cent, which is 2 ounces for each 10 gallons of milk. To ½ pint water add 2 ounces of crystals. Bring this to a boil in order to kill bacteria present and then cool. Add this solution slowly to the milk while stirring thoroughly.

5. **Incubation.** Incubate the milk at 70° F. for about 14 to 16 hours.

6. **Cooling and storing.** The finished starter, which has an acidity of from 0.75 to 0.85 per cent, calculated as lactic, should be cooled to a low temperature (40° F.). Unless the starter is to be used within a short time after cooling, it should be placed in clean, sterile, well-tinned or stainless steel cans and these kept in the refrigerator.

CHARACTERISTICS OF GOOD STARTER

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 a ropy condition.

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

DEFECTS IN STARTER

A sharp acid taste is caused by overripening 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.

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.

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.

Metallic flavor is caused by overripening 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 overripening.

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

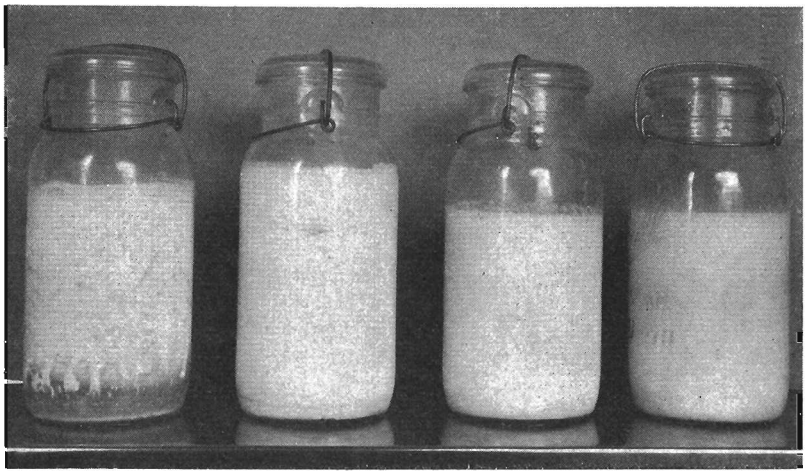

Figure 9. Poor-quality and good-quality starter. From left to right: (1) yeasty; (2) high acid, wheyed off; (3) wheyed off; (4) satisfactory.

flavor compounds are not satisfactory. To improve the flavor use milk from a different source, preferably of a higher solids-not-fat content or add citric-acid crystals before inoculation. It may also be desirable to obtain a new culture from a commercial laboratory.

Slow production of acid may be caused by the inhibition of the growth of the *Streptococcus lactis* organisms by a bacteriophage, which is a principle that hinders bacterial growth.* Since there is no method at present for eliminating the inhibitory principle, it is necessary, especially for cheese factories, to obtain a new culture of bacteria.

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.

* Nelson, F. E., Harriman, L. A., and Hammer, B. W., Slow Acid Production by Butter Cultures. Iowa Agr. Exp. Sta. Res. Bul. 256, 1939.

Table 2. CHARACTERISTICS OF THE BACTERIA IN STARTER*

Lactose fermenting bacteria	Citric acid fermenting bacteria	
Streptococcus lactis	*Leuconostoc dextranicus* (formerly *Streptococcus paracitrovorus*)	*Leuconostoc citrovorus* (formerly *Streptococcus citrovorus*)
Spheres, elongated in direction of chain.	Spheres	Spheres
0.5 to 1 micron	0.6 to 1 micron in diam.	0.6 to 1 micron in diam.
Pairs and short chains	Pairs and short chains	Pairs and short chains
Gram positive	Gram positive	Gram positive
Acid in litmus milk	Acid in litmus milk	Slight acid production in litmus milk
Complete reduction of litmus before curdling	Coagulation of litmus milk. Slight reduction of litmus at bottom of tube	Partial reduction of litmus
No digestion No gas produced		Uses citric acid in milk
Acid from dextrose, maltose, and lactose	Acid from dextrose, levulose, galactose, maltose, sucrose, and generally from lactose and mannose	Acid from dextrose, levulose, galactose, lactose
Some strains survive 60° C. (140° F.) for 30 minutes		
Growth at 10° C. (50° F.) or below and at 40° C. (104° F.) but not at 45° C. (113° F.)	Optimum temperature of growth 21° to 25° C. (69.8°–77° F.)	Optimum temperature 20° to 25°C. (68°-77° F.)
Growth in presence of 4 per cent but not 6.5 per cent salt		
No growth at pH 9.6 but growth at pH 9.2		
Final pH in broth 4.5 to 4.0		
Aerobic, facultative	Aerobic, facultative	Aerobic, facultative
Varieties:		
Streptococcus lactis var. *maltigenes*		
Streptococcus lactis var. *anoxyphilus*		
Streptococcus lactis var. *tardus*		
Streptococcus amylolactis		
Streptococcus raffinolactis		
Streptococcus saccharolactis		

* Bergey's Manual of Determinative Bacteriology, Fifth Edition, 1939, published by The Williams and Wilkins Company, Baltimore, Maryland.

Station circulars on the following are available: Cottage cheese, cultured buttermilk, acidophilus milk, cultured cream. For these, write to the Agricultural Experiment Station, Corvallis, Oregon.

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.

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