

The Technology of Sour Milk Products

by H. Eller

TALLINN 1966

XI
1A-12949

U.S.S.R.
THE MINISTRY OF THE MEAT AND MILK INDUSTRY
OF THE ESTONIAN S.S.R.

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by H. ELLER

THE INTERNATIONAL SEMINAR
FOR THE FELLOWSHIP GROUP OF THE U N O
ON THE MILK INDUSTRY IN THE ESTONIAN S.S.R.

TALLINN 1966

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Tartu Riikliku Ülikooli
Raamatukogu

203911

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INTRODUCTION

Products the manufacturing of which is based on the lactic acid fermentation, very often accompanied by alcoholic fermentation, are called sour milk products.

The lactic acid fermentation is caused by lactic acid bacteria added to pasteurized milk as starter in the processing of sour milk.

Depending on the species of bacteria various sour milk products may be obtained.

Depending on the inducers of fermentation we distinguish lactic acid fermentation products (sour milk, acidophilus milk, etc.) and lactic acid and alcoholic fermentation products, i.e. complex fermentation products (kefir, koumyss etc.).

As a result of the activity of lactic acid bacteria only lactic acid is formed in the process of lactic acid fermentation. Fermentation of this type is called homofermentative. The products of this group have specific taste, characteristic of sour milk, and compact and homogeneous coagulum, without gas bubbles.

In the process of complex fermentation when not only lactic acid bacteria but also yeast-fungi grow in milk, alcohol, carbon dioxide and volatile acids are formed beside the lactic acid. This is called hetero-fermentative process. The coagulum of these products is penetrated by very small gas bubbles and can be easily shattered by shaking. That is the reason why these products are of homogeneous, sour-cream-like composition.

NUTRITIVE AND DIETARY QUALITIES OF SOUR MILK PRODUCTS

Sour milk products are easier and quicker assimilated by the organism, as compared with the assimilation of whole milk.

Table 1

Duration of assimilation in hours	Assimilation in per cents	
	milk	sour milk
1	32	91
2	36	92
3	44	95.5

A better assimilation of sour milk products is due to the fact that these products affect the secretory activity of the stomach and intestines. As a result the glands of digestive tract intensify secretion of ferments accelerating the assimilation of food.

Such a great difference in the assimilation of milk and sour milk depends on the change of properties of proteins in the process of coagulation.

Besides, the coagulum of sour milk products obtained as a result of lactic acid and alcohol fermentation, is penetrated by carbondioxidegas bubbles. Owing to this the ferments of digestive tract split it easier.

Having pleasant, refreshing and pungent taste sour milk products evoke appetite and improve the general condition of the organism.

Regular use of sour milk products in food strengthens also the nervous system. As a result of the activity of milk bacteria, vitamins indispensable for the human organism are accumulated in sour milk products.

Dietary and therapeutic qualities of sour milk products are determined by micro-organisms and substances, which are formed as a result of biochemical processes accompanying acidification of milk. The Russian scientist Mechnikov called attention to these qualities of sour milk products.

In his opinion the wide use of sour milk products by the population of the Caucasus and the Balkan Peninsula accounts for

their longevity. Mechnikov held the view that the bacteria found in sour milk products are able to live in the human digestive tract and have a favourable influence on the organism. As a rule pyogenic bacteria can be found in the microflora of the large intestines. These bacteria use for their activity indigested portions of food and produce toxins (indole, skatole, etc.). Absorbed into the blood they poison continually the whole organism.

Lactic acid bacteria carried into the organism with sour milk products produce lactic acid creating acidic medium in the intestines. Pyogenic bacteria cannot grow in an acidic medium and the possibility of poisoning the organism is eliminated.

Mechnikov's theory is correct in its essentials. Mechnikov held the view that *Bact. bulgaricum* can be found in the intestines. However, later investigations have proved the presence of *Bact. acidophilum* in the intestines. They are more resistant in an alkaline medium and owing to this they can develop and grow in the alkaline medium of the intestines. Due to the fact that *Bact. acidophilum* is capable of using other sugars, its activity can be carried on in the absence of lactic sugar.

The therapeutic effect of sour milk products is based on the fact, that lactic acid bacteria and yeasts exercise a bactericidal influence on pathogenic microbes. These bactericidal properties are due to antibiotic activity of the yeasts and bacteria growing in sour milk products. These products contain such antibiotics as nizin, lactoline, streptocine etc. The antibiotics mentioned here have a bacteriostatic effect on certain micro-organisms. In order to increase the therapeutic effect of sour milk products one should take into consideration the bactericidity (capability of producing antibiotics) of the cultures of milk bacteria and yeasts chosen for starter.

Sour milk products are especially necessary for curing various diseases where they are used together with medical preparations.

Good results can be achieved using acidophilus milk for treatment of tuberculosis. Acidophilus milk has a favourable ef-

fect also in treating dysentery, typhoid, gastritis.

Kefir is widely used for treating digestive tract disturbances, anaemia, atherosclerosis and other diseases.

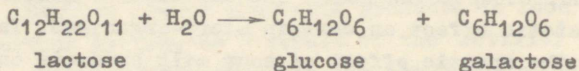
Sour milk products can also be manufactured of skim milk. It is highly advisable that people, who cannot take food rich in fat should use sour milk products made of skim milk. As to their curing and dietary properties sour skim milk products are of equal value with full milk products. They are not equal to full milk products in their nutritive value because of the absence of fat.

BIOCHEMICAL PROCESSES OCCURRING AT THE PRODUCTION OF SOUR MILK PRODUCTS

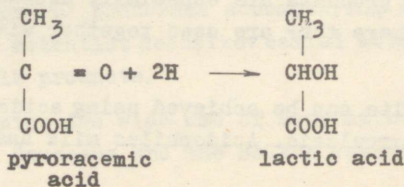
Milk is a favourable medium for micro-organisms and for lactic acid bacteria in particular. As a result of the lactic acid fermentation caused by these micro-organisms the formation of lactic acid from lactic sugar takes place. Due to lactic acid, milk obtains a sour flavour and the casein present in milk coagulates. In the course of souring of milk the following processes occur.

Microbes carried into milk with starter produce the milk ferments into the milk everyone of which is affecting a certain substance.

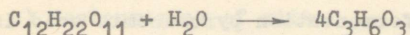
Under the influence of ferment lactase the lactose molecule decomposes into two monosaccharides: glucose and galactose.



A number of fermentative changes result in forming two pyroracemic acid molecules from glucose and galactose. The latter is reduced to lactic acid under the influence of a ferment ohydrase.



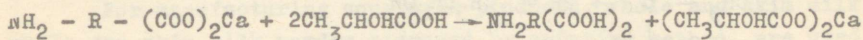
Thus, 4 molecules of lactic acid are formed from one molecule of lactose. The general equation for the lactic acid fermentation can be written down as follows:



At the optimum temperature for lactic acid bacteria (30 - 45 °C) the lactic acid fermentation is intensified. The higher the temperature of milk the lower the acidity at which its coagulation takes place.

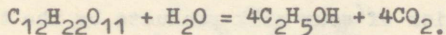
Casein is present in milk in the form of the salt of calcium. Lactic acid eliminates calcium from casein. The reaction gives insoluble casein acid and calcium lactate.

The process described above can be expressed by means of the following equation:



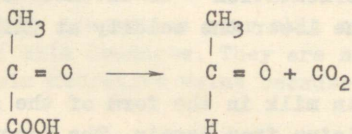
Despite favourable conditions, the lactic acid fermentation slowly ceases although only a minor part of lactose, dissoluble in milk, has fermented into lactic acid. This is due to the fact that the lactic acid produced in the process of fermentation begins to inhibit the activity of lactic acid bacteria and when a certain concentration of lactic acid is achieved the further formation of lactic acid even ceases.

The limit of fermentation is 110 - 140 °Th in order to avoid too sour flavour of sour milk products. Additional processes occurring parallel to lactic acid fermentation result in formation of volatile acids, alcohol, carbon dioxide and other products. The alcohol fermentation is caused by yeasts and some species of bacteria. Yeasts which ferment lactic sugar are not able to decompose other sugars, for instance saccharose. Simultaneously baker's yeast as well as beer and wine yeasts are not able to ferment lactose and consequently cannot grow in milk without saccharose. The alcohol fermentation can be represented in the form of the following equation:

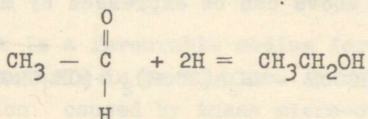


In general the alcohol fermentation is a more complicated process. It gives a number of intermediate products including pyroracemic acid.

At the final stage of fermentation pyroracemic acid is decomposed into acetaldehyde and carbon dioxide under the influence of a ferment carboxylase.



Acetaldehyde reduces into ethylalcohol



As a result of subsidiary processes concurrent with the alcohol fermentation, ethers and other alcohols are formed. But the quantity of these by-products is small.

Some lactic acid bacteria secrete ferments which cause partial decomposition of proteins into simpler compounds (peptonization). This process occurs to a greater extent in processing kefir and koumyss and to a lesser extent in sour milk.

Milk fat in sour milk products remains practically unchanged. This can be explained by the fact that at pasteurization of milk at a temperature of 80 °C fat decomposing ferment - lipase is inactivated and therefore this ferment is lacking in sour milk products.

THE GENERAL TECHNOLOGY OF SOUR MILK PRODUCTS

In our republic two methods of making sour milk products are known. These are the thermostat and the reservoir (tank) methods.

Production of sour milk products by the thermostat method is carried out in accordance with the following scheme.

- 1) Obtaining of milk and estimation of its quality.
- 2) Refining of milk.
- 3) Standardizing of milk.
- 4) Pasteurizing of milk.
- 5) Homogenizing of milk.
- 6) Cooling of milk.
- 7) Addition of starter.
- 8) Bottling of milk.
- 9) Souring of milk in a thermostat.
- 10) Cooling and ripening of products.
- 11) Determination of the quality of products.

At the production of sour milk products standardizing and homogenizing are not carried out in case of skim milk and butter-milk.

For manufacturing sour milk products, whole and skim milk, whole and skim milk powder prepared by spraying method, are used. In addition to the products mentioned above, condensed milk with sugar, beet sugar, berry and fruit jam, spices, vanillin, cinnamon, etc. are sometimes used.

Raw and auxiliary materials must correspond to the requirements of standard specifications. The acidity of milk should not exceed 20 - 24 °Th. The fat content must ensure the fat percentage of 3.2 in the finished product.

Standardizing of Milk

Finished products must correspond to the fixed technical requirements. For this reason milk must be standardized. Standardizing of milk for manufacturing majority of products lies in reducing or increasing the fat content of milk to 3.2 per cent.

The following milk standardizing methods are known.

1) Milk is standardized in tanks. Its fat content is reduced by adding skim milk to it. The quantity of skim milk added can be determined by means of the following formula

$$K_{kp} = \frac{K_p (R_p - R_s)}{R_s - R_{kp}}$$

where K_{kp} - quantity of skim milk necessary for standardizing (in kg)
 K_p - quantity of whole milk to be standardized (in kg)
 K_s - quantity of standardized milk (in kg)
 R_p - fat content of whole milk (in per cent)
 R_s - fat content of standardized mixed milk (in per cent)
 R_{kp} - fat content of skim milk (in per cent)

2) Milk is standardized in tanks, its fat content being increased by adding cream or rich-in-fat milk. The quantity of cream or rich-in-fat milk necessary for standardizing can be found by means of the following formula:

$$K_k = \frac{K_p (K_s - K_p)}{R_k - R_s}$$

where K_k - quantity of cream (in kg)
 R_k - fat content of cream (in per cent).

3) Milk is standardized in the stream. All the milk is conducted into a separator meant for standardizing. Out of the separator flow milk and cream with prescribed fat content. The deviation from the prescribed fat content is usually 0.1 - 0.05 %.

The fat content of standardized milk depends on that of the whole milk used. For this reason the milk which is flowing into the separator for standardizing, must have a constant fat content. If the fat content of milk changes, the position of the regulating valves must also be changed.

At standardizing of milk we must take into account the amount of the added starter. Usually 5 % of starter is added manufacturing sour milk products. Thus the finished product must contain 5 parts of starter and 95 parts of milk. These 95 parts of milk must ensure the fat content of 3.2 per cent of the finished product. The fat content of milk which is soured by adding 5 per cent of the starter made of the skim milk can be found out by means

of the following formula

$$R_p = \frac{3.2 \times 100}{95} = 3.4 \text{ per cent}$$

Using larger or smaller amounts of starter the fat content of the milk before fermentation must be higher or lower respectively.

It is expedient to prepare the starter of standardized milk. In this case adding of starter into milk will not affect fat content.

Pasteurizing of Milk

It has been proved that milk pasteurized at a low temperature for a short time is not fit for manufacturing sour milk products of high quality. Souring such milk gives weak fragile coagulum from which whey separates easily. The increase of acidity is slow due to the hindered growth of milk bacteria.

Investigations have shown that the reasons for inadequate development of bacteria in the milk pasteurized at a low temperature are changes going on in the molecule of casein. At these temperatures the extension and dehydration of casein particles take place and probably this makes it difficult for the lactic acid bacteria to use casein as a source of nitrogen. At higher temperatures contrary changes take place, namely hydration and partial hydrolysis of casein, therefore lactic acid bacteria can easily acquire nitrogen. The growth of microbes is accelerated and formation of acid increased. This enables to form a compact coagulum, whereas a thin precipitate of albumin coagulated at a high temperature improves the consistence of the product.

Pasteurization of milk at a temperature of 76 - 78 °C for 30 min. enables to obtain a milk product with a good coagulum and consistence. But such conditions of pasteurizing are practically inconvenient because in this case extra tanks are needed for preserving milk during the period of pasteurization. This calls for extensive production premises.

The lactic acid fermentation proceeds more intensively when

acidifying milk is pasteurized at temperatures from 85 to 87°C. As a result a compact coagulum is formed which ties well up whey.

While manufacturing sour milk products milk is usually heated at temperatures from 85 to 90°C and kept at these temperatures for 10 min. Under production conditions two methods for pasteurization and cooling of milk are used. These are continuous and periodic methods.

In case of the first method plate or pipe (tube) pasteurizers are used together with a tank.

Milk in the pasteurizer is heated up to a temperature of 85 - 90° and conducted into a tank where it is kept for 10 min. In the tank milk proceeds to a plate pasteurizer, first into regenerative and then into water section, where milk is cooled to the temperature of fermentation.

In the case of periodic pasteurization and cooling method plate pasteurizers and prolonged pasteurizing tanks are used. Not depending on equipment milk is heated to a temperature of 85 - 90°C and kept at the temperature as high as 80° in the prolonged pasteurizing tank for 10 min. After that the milk is cooled to the temperature of souring.

Homogenizing of Milk

Homogenizing improves remarkably the consistence and flavour of sour milk products. Milk is usually homogenized at the temperature of pasteurization at pressures from 150 to 200 atm.

ADDITION OF STARTER, BOTTLING AND SOURING OF MILK

Starter is added to milk immediately after cooling it till the temperature of souring. The temperature of souring depends on the kind of a sour milk product being near to the optimum temperature of the growth of bacteria which are used for souring.

After removing the upper layer of the starter it is carefully

stirred and added to milk through a metal sieve. In case of a large amount of production the starter is conducted into the tank by means of a pump.

The average amount of starter added is 5 per cent of the whole amount of milk. Larger amounts of starter are not recommended because preparation of a large amount of ferment calls for additional equipment and floor space.

At the present time there is a tendency to reduce the quantity of the starter added. It is quite possible when sanitary and hygienic conditions are observed and when stable working conditions of pasteurizers are guaranteed. A number of home and foreign enterprises use reduced norms (1.5 - 2 per cent).

After adding the starter the milk is carefully stirred and bottled and corked.

Paper-package for sour milk products is achieving wider use. This method of bottling does not demand bottle-washing machines and stores for empty bottles.

Corked bottles are conducted into a thermostat, where the temperature corresponds to the optimum temperature necessary for the development of lactic acid bact. The formation of a coagulum and the degree of acidity indicates whether the product is ready or not. The formation of a coagulum takes place at 60 °Th. The coagulum must be compact and homogeneous. No whey is allowed.

By the time of ripening of the product the acidity of ordinary sour milk and acidophilus milk is expected to be 70 - 75 °Th and 80 - 85 °Th respectively. For this reason the products are kept in the thermostat for some time after the formation of the coagulum.

As a rule, duration of souring depends on the acidification temperature and on the amount as well as the activity of the added starter. Then the product is placed into a cooling chamber and is cooled there till ripening. The average temperature in the chamber must be kept about 0 °C, it must not exceed 6 °C.

An intensive circulation of air is created with the aid of ventilation in order to intensify cooling of the product. Rapid

cooling of the product helps to inhibit the fermentation of lactic acid. Practically this process ceases at a temperature of 8 °C. If cooling of the product is not carried out in proper time, its acidity increases causing separation of whey. Using too high temperatures also makes for separation of whey. After cooling the product is left to ripen in the cooling chamber for 6 hours. In the process of ripening casein becomes puffy and as a result of this free water is partially tied up, the consistence of the product becoming more compact. In case of the products with complex fermentation the formation of spirits (alcohol) and carbon dioxide takes place. The temperature required for preserving sour milk products till delivery to the consumer, must not exceed 8 °C.

Any kinds of sour milk products can be made by the thermostat method.

PRODUCTION OF SOUR MILK PRODUCTS BY RESERVOIR (TANK) METHOD

The difference of the reservoir method lies in the fact that adding of starter, cooling and ripening of the product take place in the same tank. The finished product of a sour-cream-like consistence is bottled. The reservoir method requires using of universal tanks which are supplied with intermediate coolers and mixers.

This method is used for production such sour milk products as kefir, acidophilus milk, acidophiline, acidophiline yeast milk.

Depending on the equipment available at the factory various technological schemes of the reservoir method can be used.

Various automatic machines adjusted for bottling semiviscous products are used in the milk industry for bottling sour milk.

Observations have shown that at the time of conservation of cooled and mixed products in a tank or in bottles in the cooling chamber its viscosity increases considerably. But this does not concern cooled products with intact coagulum.

Production of sour milk products by reservoir method

has the following advantages:

- 1) No bulky thermostat is needed. This enables a more efficient use of the floor space. The quantity of production per sq. m. of the floor space increases;
- 2) It enables to organize a more completely mechanized and automated production process.

THE TECHNOLOGY OF VARIOUS SOUR MILK PRODUCTS

Sour Milk

It is the most wide-spread of the sour milk products. According to the bacteria culture used we distinguish between ordinary sour milk, Mechnikov's sour milk, acidophilus sour milk, etc.

Ordinary Sour Milk

It is made of pasteurized milk by means of acidifying it with the pure culture of mesophilial lactic acid bacteria (*Str. lactis*). Starter is added as much as 3 - 5 per cent. Milk is soured at a temperature of 36 - 38 °C until it acquires an acidity of 75 °Th. Ordinary sour milk has a compact coagulum and a bit mawkish flavour.

Mechnikov's Sour Milk

It is made of pasteurized whole milk soured by means of the culture of lactic acid streptococci (*Str. lactis*) to which the culture of *Bact. bulgaricum* has been added. To 4 - 7 parts of lactic acid streptococous starter 1 part of the starter of *Bact. bulgaricum* is added. 5 per cent of such starter is added to the milk with temperature of approximately 40 °C. Then the milk is filled out into 0.2 - 0.5 l jars. The jars are corked and put into a thermostat where the temperature is 38 °C. Acidifying is finished when the acidity of sour milk rises as high as 70 - 75 °Th. The finished product must have a full taste and aroma of sour milk, a compact coagulum without any gas formation and separation of whey.

The acidity of the finished product extends from 75 to 110 °Th.

The flavour of sour milk can be improved by adding to the milk combined starter which contains various stems of lactic acid streptococci and rods.

Acidophilus Sour Milk

It differs from Mechnikov's sour milk by the presence of cultures of *Bact. acidophilum* in the starter which is added to milk, whereas in the starter used for Mechnikov's sour milk *Bact. bulgaricum* is present.

Optimum temperature necessary for the development of acidophilus *bact.* is 45°C . In order to enable simultaneous growth of acidophilus *bact.* and mesophilial lactic acid streptococci the milk is acidified at a temperature of $40 - 42^{\circ}\text{C}$. As far as the rest of the technological process is concerned it is the same as that of the production of Mechnikov's sour milk. The acidity of the finished product must be limited from 75 to 110°Th . When the product is ready it is filled out into 0.2 - 0.5 l. jars.

ACIDOPHILUS SOUR MILK PRODUCTS

Acidophilus Milk

It is manufactured by souring pasteurized whole milk by means of the pure culture of acidophilus rods (*Bact. acidophilum*).

Five per cent of starter is added to pasteurized milk cooled to a temperature of $45 - 48^{\circ}\text{C}$. For souring milk the stems of acidophilus bacteria (either slimy or not) are used. Slimy stems give a viscous consistence to the finished product, but at the same time they do not form acid intensively. Acidophilus milk manufactured by means of slimy stems is too viscous and lacks the required pungent taste.

Slimy stems are strong acidifiers, but the only use of them gives a product with exceedingly sour taste.

In general use is made of both stems in different proportions depending on what kind of consistence of product is desired. Each culture is prepared separately. Usually starter is added to

milk in the following proportions: 80 per cent of non-slimy stems of acidophilus rods and 20 per cent of slimy stems.

Acidophilus rods are thermophilial bacteria, therefore milk is soured at a temperature of 42 - 45 °C. Depending on the activity of the culture the acidifying process may last for 3 - 4 hours. Acidophilus milk is filled out into 0.2 - 0.5 l bottles. The acidity of the finished product is within the limits from 90 to 140 °Th.

Acidophiline

For production acidophiline, the milk is pasteurized at a temperature of 85 - 90 °C for 10 - 15 min. Then it is cooled to a temperature of 28 - 32 °C and mixed with 4.5 - 6 per cent of starter, which has been composed of equal volumes of three different cultures: the starter of acidophilus rods, lactic acid streptococcus and kefir fungi.

The milk mixed with starter is filled out into 0.25 l and 0.5 l bottles. Filled and corked bottles are put into a thermostat where they are held at a temperature of 18 - 25 °C until the growth of acidity to 70 °Th, and formation of a homogeneous and compact coagulum. Then acidophiline is preserved in cooling chambers at a temperature of 6 - 8 °C.

Acidophilus paste

It is produced by way of partial separation of whey from acidophilus milk. To sterilized or pasteurized milk cooled to 45 °C starter is added which contains slimy and non-slimy stems of acidophilus rods. As a result of souring we get a coagulum which is cut into cubes with the edges of 2 cm. The coagulum cut into small pieces is placed into sterilized bags which undergo self-pressing in cart-presses. Self-pressing takes some 12 - 16 hours.

When acidophilus paste is ready it has a sour-cream-like consistence. It contains 8 % of fat and about 80 % of water.

Acidophilus paste can be manufactured with such admixtures as sugar, cocoa, candied fruit, raisins. Such product has a pleasant taste and good consistence. It is an indispensable child-

ren's food. Sugar is added to the paste in the form of syrup which has been boiled and then cooled to 40 - 42 °C.

Acidophilus paste is packed into wide-necked 0.2 - 0.5 l jars and is cooled to 4 - 6 °C.

Kinds of acidophilus paste and their chemical composition are given in the following table.

Acidophilus paste	Acidity not over °Th	Content in %			t° at market- ing mo- ment not over
		fat not below	water not over	sugar not over	
Sweet with fat content 8 %	200	8	60	24	8
4 %	180	4	70	20	8
Made of skim milk	200	-	80	12	8
With fruit juice	250	8	80	28	8

Kefir

Kefir is a sour milk product obtained as a result of lactic acid and alcohol fermentation. Kefir originates from the North Caucasus.

Kefir is made of pasteurized milk which has been soured by means of a starter where kefir grains are used.

Kefir grains are formations of protein with the presence of micro-organisms. The main representatives of the microflora of kefir grains are lactic acid bacteria, lactic acid streptococci, including aroma-forming bacteria, acetic acid bacteria and yeast of milk of *Torula* type.

Until using the kefir grains are preserved in a dry state. In such a state they retain their viability although metabolism has come to an end. But under favourable conditions they reactivize again.

Observations have shown that the microbes in dry kefir grains preserve their viability over 6 months.

In preparing starter dry kefir grains are kept in warm water having a temperature of 25 - 30 °C for 24 hours. During this time the water must be changed 2 - 3 times. Then the grains are kept in warm milk. Milk is taken 10 parts to 1 part of grains. The grains are soaked until they are revived, that is until their activity has been restored. This is testified by the kefir grains rising on the surface of milk. It is advisable to stir the milk from time to time while souring it with kefir grains. Thus the aeration of milk can easily be achieved, as a result of which the activity of yeasts is intensified.

Milk soured with the help of kefir grains is commercial starter. The grains are removed from the starter and then it is filtered through a sieve. The extracted kefir grains are used for preparing next quantity of commercial starter. The starter obtained must not be used for making next amounts of starters.

While cultivating the kefir grains grow in their volume. This makes it possible to remove part of them from using. For this purpose they are thoroughly washed, dried and preserved in a hermetically closed container. If necessary, the grains may be revived and used for manufacture of the next quantity of starter.

For checking up the quality of kefir grains they are washed with boiled and cooled water from time to time. Friable and slimy grains are removed when washing.

If the kefir grains are used during a long time or if the souring conditions are not observed, kefir loses its characteristic flavour, aroma and consistence and turns into a product of a sour milk type. To avoid this, new kefir grains are substituted for those which have lost their properties.

The starter in which the proportion between the kefir grains and milk is 1:20, appears to be the best. Beside lactic acid streptococci, lactic acid bacteria and yeasts also find favourable conditions for growing in such a starter.

The kefir manufactured by means of this starter obtains a characteristic flavour and aroma during a short time of souring.

The quantity of starter added in manufacturing of kefir makes 5 % of the quantity of milk. The temperature of souring of milk is 20 - 22 °C. The souring of milk at this temperature takes 14 - 16 hours.

Sometimes, to increase the productivity of the thermostat the temperature required for souring is raised to 26 - 28 °C. However, kefir is seldom cooled immediately after souring and is sent for sale without any longer preservation. In such a product the yeasts are not given the possibility of growing and due to this the product acquires properties characteristic of ordinary sour milk.

Alcohol and carbon dioxide should be present in a kefir of high quality. With the aim of better growth of yeasts after souring kefir must be kept at a temperature of 12 - 16 °C for 4 to 6 hours. The end of souring can be determined by the acidity which is expected to be in the range of 80 °Th.

For promoting the alcohol fermentation kefir is held after souring in a cooling chamber at a temperature of 6 - 8 °C. Depending on the time of preservation we distinguish between weak kefir (the period of preservation is 24 hours), average kefir (the period of preservation 48 hours) and strong kefir (the preservation is 3 days).

As to organoleptical and chemical indices kefir must correspond to the following requirements.

Flavour and aroma must be pure as characteristic of sour milk products. Consistence should be homogeneous, and resemble fluid sour cream. Gas formation is allowed as caused by yeasts or aroma forming streptococci.

As to its chemical composition kefir must correspond to the following requirements.

Data	Sort of kefir		
	weak	average	strong
Fat not below	3.2	3.2	3.2
Acidity	80-90	80-105	90-120
Alcohol	0.2	0.4	0.6
Temperature at the delivery for marketing	8	8	8

It is advisable to cork kefir bottles hermetically, in order to prevent vaporizing of carbon dioxide, because it gives kefir a thin-grained consistence and a pungent fresh flavour.

The alcohol and lactic acid fermentation in kefir can be regulated by changing the acidifying temperature. At higher temperatures the lactic acid fermentation is intensified and kefir becomes more sour. Alcohol fermentation is more intensive at lower temperatures. As a result a product with a higher fat and gas content is obtained.

The possible defects of kefir grains as sliminess, mouldiness and contamination with Bact. Coli should be mentioned.

In order to remove sliminess of kefir grains they should be kept in milk at a low temperature (near to 0 °C) for several days.

In case of mouldiness the grains must be kept in 2 per cent soda solution for 20 minutes every day.

In case of contamination of kefir grains with Bact. coli the grains are washed, poured over with sweet warm milk. The acidity of starter is let to rise to 200 °Th. Under such conditions the grains are kept for 2 - 3 days, after which they are washed carefully. This operation is repeated two or three times.

Koumyss

Koumyss is manufactured in Bashkiria, Kirgizia, Kazakhstan, that is, in the regions of horse-raising.

The main raw material for koumyss is mare milk. As to the biochemical processes taking place at manufacturing of koumyss it is similar to kefir. But mare milk differs from cow milk as to its chemical composition. This affects the course of biochemical processes and the properties of the obtained product.

Mare milk is characterized by low fat (1.5 %) and casein (1.2 %) content and by a high content of lactose (6.5 %). The proportion of casein and albumin in mare milk is 3:1, in cow milk it is 7:1. Due to a high albumine content mare milk is referred

to as albumin milk. The acidity of mare milk is 5 - 7 °Th.

In the process of souring the formation of a compact coagulum of mare milk does not take place. Casein falls out in very thin flakes which can hardly be distinguished on the tongue and which do not change the consistence of the liquid. Due to a low casein content mare milk has insignificant abilities of buffering. By increasing its acidity its pH changes rapidly.

Mainly lactic acid bact. ferment the lactic acid in koumyss. This accounts for the fact that due to an insignificant ability of mare milk to buffer, lactic acid streptococci non-resistant in an acidic medium are suppressed.

Differently from lactic acid streptococci lactic acid bacteria do not exercise a constant influence on the growth of yeasts. This explains the rapid accumulation of alcohol (2 per cent) and carbon dioxide in koumyss.

Koumyss is usually made of unpasteurized raw milk souring it with the starter specially prepared for this purpose. The composition of starter is made up by Bact. bulgaricum and milk yeasts. Commercial starter manufactured of pure cultures is soured at a temperature of 25 - 26 °C to 140 °Th. Finished starter is cooled to a temperature of 6 - 8 °C. Cooled starter is added to mare milk which has been previously heated to 32 - 34 °C. Taking into account that the acidity of milk after adding the starter is expected to be 47 °Th, a definite quantity of starter is added. Soured milk is mixed and bottled. The bottles must be corked hermetically. The milk is left to ripen at a temperature of 6 - 7 °C. At home koumyss is manufactured in bags (bourduks) made of skin of animals.

Fresh mare milk is poured into bags with capacity of 25 - 30 l.

Fermentation is caused by the natural starter. The precipitation of aged strong koumyss gives us one of such starters, called "kor" (dry koumyss yeast or grains). The precipitation is thoroughly washed, dried and kept at a low temperature in closed vessels. Bacteriological examinations show that the starter of this type contains lactic acid bacteria and yeasts.

Milk poured into the bag is carefully stirred so that it becomes mixed with the starter which is at the bottom and in folds of the bag. Due to the fermentation of lactic acid, milk sours. During subsequent cooling of milk, lactic acid fermentation is slowed down. But alcohol fermentation is going on.

After every use of koumyss fresh milk is poured into the bag till koumyss retains its pleasant and refreshing taste.

When the flavour of koumyss deteriorates, the bag is washed, dried and disinfected.

Industrial production of koumyss from skim cow milk is carried out in the following way. In order to decrease protein content and raise carbo-hydrate content of skim cow milk 20 per cent of water and 5 per cent of sugar respectively is added to it. Standardized skim milk is pasteurized at a temperature of 90 - 96 °C and is kept at this temperature for 15 - 30 minutes. Then milk is cooled to 35 - 37 °C and soured with 3 - 5 per cent starter the acidity of which ranges from 75 - 80 °Th and which consists of 75 per cent of *Str. lactis* and 25 per cent of *Bact. acidophilum* or of the same quantities of *acidophilus* rods and *Bact. bulgaricum*. At a temperature of 35 - 37 °C the souring of milk to an acidity of 60 - 65 °Th takes 4 or 5 hours. At 30 - 32 °C it takes 16 - 18 hours.

Sour milk is mixed carefully till a homogeneous consistence is achieved. Then it is cooled to 30 °C and the starter consisting of bread and champagne yeasts is added (2.5 g of yeast per l of koumyss). After previous stirring of milk it is poured over with standardized skim milk (the temperature of skim milk is 30 °C) and is kept at the same temperature for 6 - 8 hours.

For making weak koumyss, yeast starter is added when the acidity of milk is 65 - 70 °Th, in case of medium and strong koumyss the acidity of milk is expected to be 65 - 70 °Th and 90 - 95 °Th respectively.

After adding the starter the product is mixed carefully and is held so for 1 - 2 hours till the formation of gas bubbles. When the beverage is ready, it is bottled and placed into a chamber for ripening at a temperature of 10 - 12 °C.

Weak koumyss ripens within 4 - 6 hours, medium koumyss within 8 - 10 hours and strong koumyss within 12 - 16 hours. Ripened koumyss is cooled to 2 - 4 °C and preserved at a temperature of 4 - 8 °C.

The requirements for the chemical composition of koumyss are given below.

Koumyss	Acidity	Alcohol content (in per cent)
Weak	70 - 80	0.6 - 1.0
Medium	81 - 105	1.0 - 1.5
Strong	106 - 130	not over 2.5

SOUR MILK PRODUCTS ENRICHED WITH VITAMIN C

Kefir and sour milk enriched with ascorbic acid are meant for small children and people working under unhealthy conditions.

As raw material for these products milk of a high quality and ascorbic acid are used.

Before pasteurization ascorbic acid is added to standardized milk in the following proportions: milk for small children - 100 g per ton of milk, milk for grown-up people - 200 g per ton of milk. Ascorbic acid is dissolved in 5 l of milk before adding it to milk.

Milk enriched with vitamins is pasteurized, soured and bottled in conventional manner.

Products enriched with vitamins are preserved not over 20 hours at a temperature of 2 °C.

SOUR MILK PRODUCTS WITH A HIGHER CONTENT OF TOTAL SOLIDS

These products can be manufactured of pasteurized milk, adding 3 - 5 per cent of skim milk powder.

As a rule such a mixture is used for making ordinary as well as

sweet sour milk. Finished product has a higher nutritive value and a very compact consistence.

Technological process of manufacturing sour milk products with higher content of total solids is similar to that of manufacturing these products of ordinary milk.

THE TECHNOLOGY OF MAKING SOUR CREAM

Sour cream is manufactured of sweet cream by acidifying it with pure cultures of lactic acid bacteria. Technological process for making sour cream consists of the following operations:

- 1) standardizing of cream
- 2) pasteurizing of cream
- 3) homogenizing of cream
- 4) cooling of cream to the acidifying temperature
- 5) adding of starter
- 6) souring of cream
- 7) determination of the end of souring
- 8) cooling of sour cream
- 9) bottling of sour cream
- 10) ripening of sour cream and preservation till marketing.

According to the standard specifications sour cream is expected to contain 30 per cent of fat. If starter to be added to sweet cream, forms 5 per cent and is made of skim milk, the cream must be standardized to 31.6 per cent, in order to get sour cream with fat content of 30 per cent.

Standardized cream is pasteurized at 85 °C without later preservation. This pasteurization temperature ensures sufficient hydration of proteins, as a result of which sour cream with compact consistence is obtained. But a prolonged pasteurization at high temperatures may cause melting of fat. This lowers the quality of sour cream.

After pasteurization cream is homogenized. Homogenizing of cream improves its quality and prevents separating of whey.

Cream is homogenized at a temperature of 60 °C and at a

pressure of 100 - 120 atm. After homogenizing cream is cooled to the acidifying temperature. The choice of this temperature depends on the season and production conditions. The acidifying temperature is 21 - 22 °C in winter and 18 - 19 °C in summer.

The starter for acidifying cream is prepared of pure cultures of lactic acid bacteria. The composition of the starter is made up by *Str. lactis*, *Str. cremoris* and aroma-forming bacteria, *Str. diacetylactis* (*Str. citrovorus*, *Str. paracitrovorus*).

Depending on the temperature the acidifying process lasts for 14 - 20 hours. After adding the starter cream is stirred from time to time during first 2 - 3 hours, so that the starter and fat will be mixed up homogeneously in the cream. The end of souring is determined by the consistence and acidity of sour cream. The latter must be 75 - 80 °Th.

Achieving the necessary acidity, cream is cooled to 5 - 8 °C. After cooling the cream is filled out into 200 g jars or 38 l aluminum containers. Bottled sour cream is stored in a cold room, where the temperature is 5 - 8 °C. Cream is kept there till ripening for 24 - 48 hours.

In the course of ripening milk fat solidifies and proteins expand. As a result, the sour cream becomes thicker and acquires a compact consistence.

Cream tanks or universal tanks used for manufacturing sour cream can also be used for cooling of cream. Cream is bottled after ripening.

Sour cream meant for marketing must correspond to the following requirements:

Fat content	-	30 per cent
Acidity	-	65 - 90 °Th
Temperature at the delivery for marketing	-	10 °C

According to organoleptic indices sour cream must correspond to the following requirements.

Flavour and aroma: pure, with a weak pasteurizing flavour and aroma; no side-flavours or side-odours.

Consistence: compact, moderately dense; no protein or fat grains; with lustrous surface.

Colour: from white to yellowish.

It is not allowed to market sour cream with thin consistence.

Curd

Curd is also a sour milk product. It has a high nutritive and dietary value. Its calorificity is 1500 - 2400 cal/kg.

Curd contains 14 - 19 per cent proteins, 9 - 18 per cent fat, mineral substances, e.g. 3 g/kg of calcium necessary for metabolism and formation of bone ; 2.35 - 4.14 g/kg of phosphorus which is of great importance for the functioning of the central and peripheral nervous system, and in the metabolism of fats, proteins and carbo-hydrates; 6 mg/kg of iron which being a part of hemochromogen belongs to the composition of hemoglobin and brings about the oxydation of the latter into hematin; 50 mg/kg of magnesium which plays an important part in the metabolism of mineral substances, especially calcium, and in growing process of the organism; near to 0.41 g/kg of sodium, which brings about the efficient increase in the body mass; 1.52 g/kg of chlorine which takes part in the regulation of osmotic pressure and water exchange.

Curd is manufactured of pasteurized whole milk, of standardized or skim milk, acidifying it with starters prepared of pure cultures of mesophilial lactic acid bacteria.

It is allowed to manufacture curd of unpasteurized raw material. In this case it is processed into semi-products, e.g. boiled pies, curd outlets, etc. It is used in manufacturing processed cheese and in cookery where it undergoes thermic processing instead of pasteurization.

Depending on the raw material used for manufacturing of curd, we distinguish between high-fat, medium-fat and fat-free curd. By method of processing difference is made between acid and acid-rennet curd.

As to their chemical composition curds must correspond to the following requirements.

Table 5

Data	Curd with fat content 18 per cent	Curd with fat content 9 per cent	Fat-free curd
1) Fat content in per cent not lower than	18	9	-
2) Water content in per cent not over	65	73	80
3) Acidity in °Th not over	210	220	210

Organoleptic qualities of curd are given in table 6.

Table 6

Data	Characteristics
1) Flavour and odour	Pure, fine odour of sour milk. A weak side-taste or the food.
2) Consistence	Fine, homogeneous. Not uniform, slightly greasing and in case of fat-free curd slight secretion of whey and friability is allowed. No solid caseinized pieces.
3) Colour	White, yellowish, with a slight hue of cream. Uniform in all the mass of curd.

MAKING OF CURD BY ACID AND RENNET METHOD

The acid and rennet method of manufacturing of curd proceeds as follows.

- 1) Standardizing of milk.
- 2) Pasteurization of standardized milk.
- 3) Adding of starter, calcium chloride and rennet.
- 4) Souring of milk.
- 5) Processing of coagulum.
- 6) Pressing of curd.
- 7) Cooling of curd.
- 8) Packing of curd.
- 9) Evaluation of quality.

Curd is made of whole, standardized or skim milk, the acidity of which does not exceed 22 °Th.

For standardizing milk special tables are used which are drawn up separately for pasture and stall-feeding period. The table gives the required fat content of the mixture depending on the fat content of milk and the expenditure of whole or skim milk per 100 kg of standardized milk.

Whole, standardized and skim milk are pasteurized at a temperature of 80 °C with the holding period of 20 - 30 minutes.

Standardized and pasteurized milk is cooled to 30 - 32 °C and acidified. About 5 per cent of starter is added.

When the acidity of milk is as high as 32 - 35 °Th, 40 per cent calcium chloride solution is added: 500 g water-free salt per 1000 kg milk. Precipitated calcium salts substitute calcium chloride. For this reason the coagulum obtained is solid. After mixing the milk carefully rennet is added in the proportions 1 g of rennet of normal activity per ton of standardized milk (100,000 units) or 0.8 g per ton of skim milk.

Rennet is added to the milk in the form of 1 per cent aqueous solution.

Rennet makes for the formation of compact coagulum with low acidity.

In such processing a secondary cooling of coagulum is unnecessary because under the influence of rennet shrinkage of the coagulum takes place and drying of the coagulum proceeds under normal conditions.

After adding rennet milk is carefully stirred and is left to ripen till the formation of a normal coagulum. The end of coagulation is determined by the acidity and character of the coagulum. To the end of coagulation acidity is expected to rise to 58 - 60^oTh. The duration of souring at 30 - 32 °C is 6 - 8 hours. Timely determination of the end of souring is extremely important in making curd. In case coagulum is obtained from insufficiently soured milk the output of curd decreases. In case of over-acidifying sour curd with greasy consistence is obtained.

In order to prevent rise of acidity, whey must be extracted from the coagulum without delay. For this purpose coagulum is cut into cubes with dimensions 2 x 2 x 2 cm. The acidity of the coagulum is let rise to 77 - 79 °C until it becomes more compact and until whey separates. Then coagulum is put into sacks and placed into cart-presses for self-pressing for 1 - 2 hours. In order to achieve a more complete extraction of whey curd is pressed in cart-presses. For the same purpose special centrifuges can be used.

Pressed curd is cooled to 3 - 8 °C and packed.

MAKING OF CURD BY ACID METHOD

Milk is soured by means of a starter without using rennet. This method is usually intended for making fat-free curd. Souring temperature is 30 - 32 °C in summer and 34 - 36 °C in winter. At the end of coagulation the acidity of the coagulum is expected to be 70 - 75 °C. For better separation of whey the coagulum is cut into cubes with dimensions 2 cm. Then the coagulum is heated to 36 - 40 °C. While heating the coagulum is carefully stirred. Achieving the required temperature (36 - 40 °C) the coagulum is held at this temperature for 20 minutes. Then whey is extracted and self-pressing and pressing follow.

Pressed curd is cooled to 8 °C.

MAKING OF CURD BY SOLUTION METHOD

Milk intended for manufacturing of curd by this method is refined in a centrifugal cleaner and pasteurized at 80 °C, the holding period being 20 - 30 sec. Separation of milk follows. Obtained cream with the fat content of 50 - 55 per cent is cooled to 5 - 8 °C and conducted into a preservation tank.

Skim milk which comes out of the separator flows into a tank where souring takes place. 5 per cent starter, calcium chloride and rennet in fixed quantities is added. When acidity has risen to 75 °Th, the coagulum is conducted by means of a pump into a special separator where whey is separated from the coagulum.

Finished fat-free curd is conducted by means of a special pump into a mixer where cream is added in the quantity ensuring the required fat content of the finished product.

After careful stirring the curd is cooled and packed.

Making of curd by solution method has its advantages. It enables to mechanize the technological process of curd production. Besides, it is possible to reduce loss of fat with whey and improve the quality of curd.

The amount of cream to be added, in order to achieve the curd with required fat content, can be found by means of the following formula.

$$K = \frac{A \cdot R_A}{R_k}$$

where K - amount of cream (in kg)

A - amount of curd obtained (in kg)

R_A - fat content of the curd obtained in per cent (9 or 18 per cent)

R_k - fat content of cream

In order to obtain curd with the fat content of 9 or 18 per cent, fat-free curd with a fixed water content must be prepared. If the fat-content of the cream to be added is 50 per cent, fat-free

curd intended for making medium-fat curd (9 per cent) must contain 78.9 per cent of water; for making fat curd (18 per cent) the water content of fat-free curd must be 75.5 per cent. In case of the cream with fat content of 55 per cent the water content of fat-free curd is supposed to be 79.1 and 76.3 per cent respectively.

Х. Эллер

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