Chapter 11

Cultured milk products

Milk products prepared by lactic acid fermentation (e.g. yoghurt) or a combination of this and yeast fermentation (e.g. Kefir) are called fermented or cultured milks. The term **cultured** ***will be used in this chapter.***

Cultured milk is the collective name for products such as *yoghurt, ymer, kefir, cultured buttermilk, filmjölk* (Scandinavian sour milk)*, cultured cream* and *koumiss* (a product based on mares' milk). The generic name of cultured milk is derived from the fact that the milk for the product is inoculated with a starter culture which converts part of the lactose to lactic acid. Carbon dioxide, acetic acid, diacetyl, acetaldehyde and several other substances are formed in the conversion process, and these give the products their

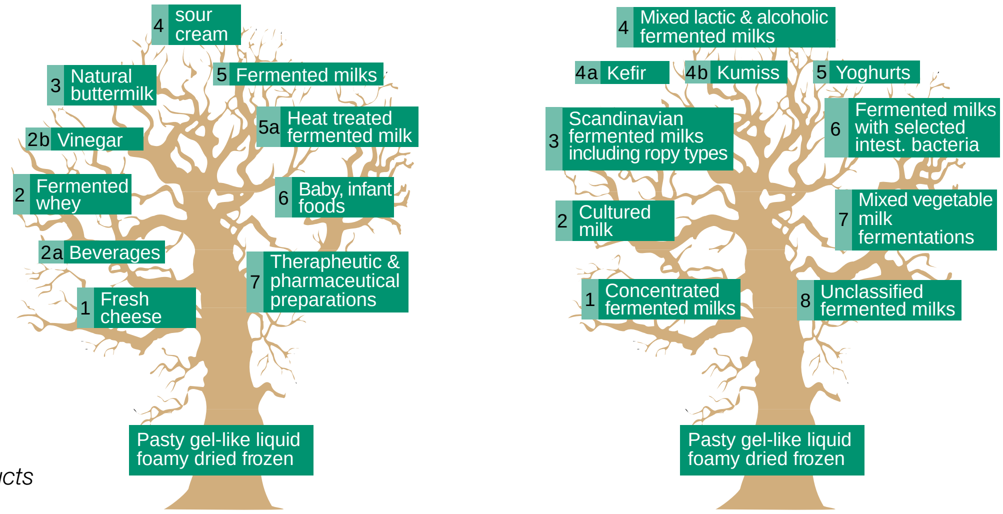


Fig. 11.1 *The cultured milk products are like branches on family trees.*

characteristic fresh taste and aroma. The micro-organisms used in the production of kefir and koumiss also produce ethyl alcohol.

Cultured milk originates from the Near East and subsequently became popular in Eastern and Central Europe. The first example of cultured milk was presumably produced accidentally by nomads. This milk “turned sour” and coagulated under the influence of certain micro-organisms. As luck would have it, the bacteria were of the harmless, acidifying type and were not toxin-producing organisms.

A legend

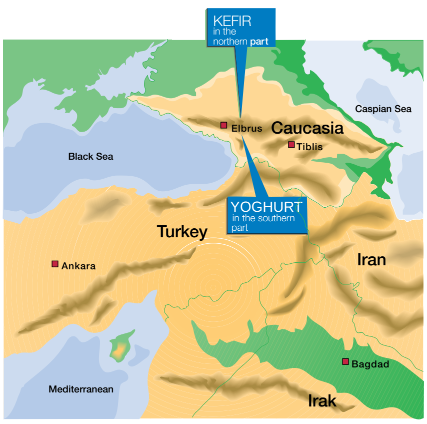


Fig. 11.2 *Mount Elbrus in the Caucasus mountain range is the birthplace of Kefir and Yoghurt.*

The legend tells that yoghurt and kefir were born on the slopes of Mount Elbrus in the Caucasus range by a miracle of Nature. Micro-organisms of various kinds happened to land in a pitcher of milk at the same time and at the right temperature, and found that they could live in symbiosis.

On the southern slope of Mt.Elbrus, micro-organisms preferring relatively high temperatures, 40 – 45°C, came together in a milk pitcher that probably belonged to a Turkish nomad, and the result was what the Turks called “Yogurut”. Some sources say that this name was introduced in the 8th century and that it was changed in the 11th century to its present form, *yoghurt*.

It is further claimed, however much truth there may be in the story, that yoghurt acts as a “preservative” against human ageing; that if you happen to meet a Cossack galloping along bareback in some Caucasian valley, he is likely to be 130 to 140 years old!

Kefir, the legend goes on to relate, was created on the northern slope by a mixture of micro-organisms that are not so fond of heat. They thrive best at 25 – 28°C. The name kefir may be derived from the Turkish language. The first syllable of the name, *kef*, is Turkish and means pleasurable, which was probably the shepherd’s first comment on the flavour.

Kefir contains several different types of micro-organisms, among which yeast is most famous as it is capable of forming alcohol. The maximum alcohol content of kefir is about 0.8%

General requirements for cultured milk production

The conversion of lactose into lactic acid has a preservative effect on milk. The low pH of cultured milk inhibits the growth of putrefactive bacteria and other detrimental organisms, thereby prolonging the shelf life of the product. On the other hand, acidified milk is a very favourable environment for yeasts and moulds, which cause off-flavours if allowed to infect the products.

The digestive systems of some people lack the lactase enzyme. As a result, lactose is not broken down in the digestive process into simpler types of sugars. These people can consume only very small volumes of ordinary milk. They can however consume cultured milk, in which the lactose is already partly broken down by the bacterial enzymes.

In the production of cultured milk the best possible growth conditions must be created for the starter culture. These are achieved by heat treatment of the milk to destroy any competing micro-organisms. In addition, the milk must be held at the optimum temperature for the relevant starter culture. When the best possible flavour and aroma have been achieved, the cultured milk must be cooled quickly to stop the fermentation process. If the fermentation time is too long or too short, the flavour will be impaired and the consistency wrong.

In addition to flavour and aroma, correct appearance and consistency are important features. These are determined by the choice of pre-processing parameters. Adequate heat treatment and homogenisation of the milk, sometimes combined with methods to increase the MSNF content, as for milk intended for yoghurt, are essential " foundation- stones" for the construction of the coagulum during the incubation period.

Some of the most important cultured milk products are described below. The production technique for other cultured products has many similarities; the pretreatment of the milk, for example, is almost the same. The process descriptions for other products therefore concentrate primarily on the production stages which differ from those in yoghurt production.

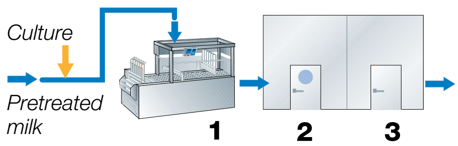


Fig. 11.3 *Set yoghurt.*
1 Cup filler
2 Incubation room
3 Rapid cooling room

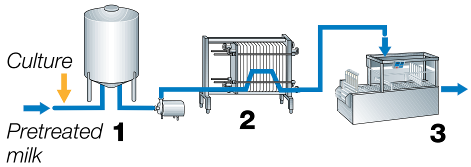


Fig. 11.4 *Stirred yoghurt.*
1 Incubation tank
2 Cooler
3 Cup filler

Yoghurt

Yoghurt is the best known of all cultured-milk products, and the most popular almost all over the world. Consumption of yoghurt is highest in countries around the Mediterranean, in Asia and in Central Europe.

The consistency, flavour and aroma vary from one district to another. In some areas yoghurt is produced in the form of a highly viscous liquid, whereas in other countries it is in the form of a softer gel. Yoghurt is also produced in frozen form as a dessert, or as a drink. The flavour and aroma of yoghurt differ from those of other acidified products, and the volatile aromatic substances include small quantities of acetic acid and acetaldehyde.

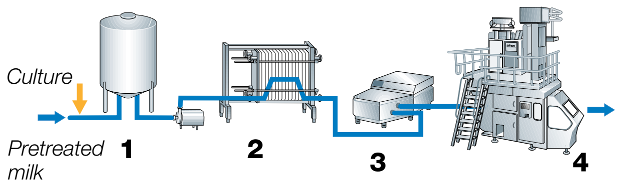


Fig. 11.5 *Drinking yoghurt.*
1 Incubation tank
2 Cooler
3 Homogeniser
4 Filling machine

Yoghurt is typically classified as follows:

- **Set type** incubated and cooled in the package, figure 11.3.
- **Stirred type** incubated in tanks and cooled before packing, figure 11.4.
- **Drinking type** similar to stirred type, but the coagulum is "broken down" to a liquid before being packed, figure 11.5.
- **Frozen type** incubated in tanks and frozen like ice cream, figure 11.6.
- **Concentrated** incubated in tanks, concentrated and cooled before being packed. This type is sometimes called *strained yoghurt*, sometimes *labneh, labaneh*, figure 11.7.

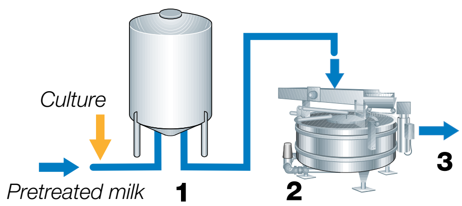


Fig. 11.6 *Frozen yoghurt.*
1 Incubation tank
2 Ice cream bar freezer
3 To hardening tunnel

Flavoured yoghurt

Yoghurt with various flavouring and aroma additives is very popular, although the trend back towards natural yoghurt is clearly discernible on some markets. Common additives are fruit and berries in syrup, processed or as a puree. The proportion of fruit usually about 15%, of which about 50% is sugar.

The fruit is mixed with the yoghurt before or in conjunction with packing; it can also be placed in the bottom of the pack before the latter is filled with yoghurt. Alternatively, the fruit can be separately packed in a "twin cup" integrated with the basic cup.

Sometimes yoghurt is also flavoured with vanilla, honey, coffee essences, etc. Colouring and sugar in the form of sucrose, glucose or aspartame, a sugar-free diet sweetener, are often added together with the flavouring.

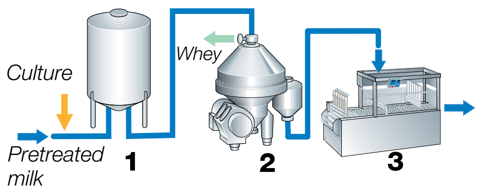


Fig. 11.7 *Concentrated yoghurt.*
1 Incubation tank
2 Separator
3 Cup filler

Stabilisers may also be added to modify the consistency when necessary.

The additives increase the DM content of the finished yoghurt; a typical composition for fruit yoghurt is:

• Fat	0.5 – 3.0 %
• Lactose	3 – 4.5 %
• Milk solids non fat (MSNF)	11 – 13 %
• Stabiliser (if used)	0.3 – 0.5 %
• Fruit	12 – 18 %

Factors affecting the quality of yoghurt

Numerous factors must be carefully controlled during the manufacturing process in order to produce a high-quality yoghurt with the required flavour, aroma, viscosity, consistency, appearance, freedom from whey separation and long shelf life:

- Choice of milk
- Milk standardisation
- Milk additives
- Deaeration
- Homogenisation
- Heat treatment
- Choice of culture
- Culture preparation
- Plant design

Pretreatment of the milk thus includes a number of measures which are all very important to the quality of the end product. The mechanical treatment to which yoghurt is subjected during production also affects its quality.

Milk for yoghurt production must:

- have a low bacteria count
- not contain enzymes and chemical substances which may slow down the development of the yoghurt culture
- not contain antibiotics and bacteriophages

Choice of milk

Milk intended for yoghurt production must be of the highest bacteriological quality. It must have a low content of bacteria and substances which may impede the development of the yoghurt culture. The milk must not contain antibiotics, bacteriophages, residues of CIP solution or sterilising agents. The dairy should therefore obtain the milk for yoghurt production from selected, approved producers. The milk must be very carefully analysed at the dairy.

Milk standardisation

The fat and dry solids contents of the milk are normally standardised according to the FAO/WHO code and principles described below.

Fat

Yoghurt may have a fat content of 0 to 10 %. A fat content of 0.5 – 3.5% is however the most usual. Yoghurt can be classified in the following groups according to the FAO/WHO code and principles:

• Yoghurt	Min. milk fat		3	%
• Partially skimmed yoghurt	Max. milk fat	less than	3	%
	Min. milk fat	more than	0.5	%
• Skimmed yoghurt	Max. milk fat		0.5	%

Dry matter (DM) content

According to the FAO/WHO code and principles the minimum MSNF is 8.2%. An increase in the total DM content, particularly the proportion of casein and whey proteins, will result in a firmer yoghurt coagulum, and the tendency to whey separation will then be reduced.

The most common ways to standardise the DM content are:

- Evaporation (10 – 20 % of the milk volume is normally evaporated).
- Addition of skimmilk powder, usually up to 3%.
- Addition of milk concentrate.
- Addition of UF retentate from skimmilk.

Milk additives

Sugar or sweeteners and stabilisers may be used as additives in yoghurt production.

Sugar or sweetener

The disaccharide sucrose, or a monosaccharide such as glucose, can be added alone or in conjunction with fruit addition. To satisfy dieters, among whom diabetics are an important category, sweeteners should be used. A sweetener has no nutritive value but tastes very sweet even in very small doses. (Note that a sweetener cannot be used as a preservative for sweetened condensed milk.)

The fruit in question usually contains about 50% sugar or a corresponding amount of a sweetener, so the required sweetness can normally be supplied by adding 12 to 18% fruit.

It should be noted that adding too much sugar (more than 10%) to the milk before the inoculation/incubation period has an adverse effect on fermentation conditions because it changes the osmotic pressure of the milk.

Stabilisers

Hydrophilic colloids can bind water. They increase the viscosity and help to prevent whey separation in yoghurt. The type of stabiliser and the rate at which it should be added must be determined experimentally by each manufacturer. The product may acquire a rubbery, hard consistency if the wrong stabiliser, or an excess of stabiliser, is used.

Correctly produced, natural yoghurt requires no addition of stabilisers, as a firm, fine gel with a high viscosity will occur naturally. Stabilisers can be used in fruit yoghurts and must be used in pasteurised yoghurt. Stabilisers (0.1 – 0.5 %) such as gelatin, pectin, starch and agar-agar are the most commonly used substances.

Stabilisers for yoghurt are:

- gelatin
- pectin
- agar-agar
- starch

Deaeration

The air content of the milk used to make cultured milk products should be as low as possible. Some admixture of air is however unavoidable if the MSNF content is increased by addition of milk powder. If this is done, the milk should be deaerated as part of the subsequent processing.

When the MSNF content is increased by evaporation, deaeration is a part of that process.

Table 11.1

Influence of homogenisation and heat treatment on the viscosity of a cultured milk (Swedish filmjölk).

Pressure at 60°C MPa	Viscosity = flow-off time in **seconds** at 20°C Ordinary past. milk (72°C/20 sec)	Highly heated milk (95°C/5 min)
0	5.7	15.0
2.5	5.6	14.6
5.0	7.1	15.8
7.5	8.0	19.0
10.0	8.9	22.1
15.0	10.4	28.7
20.0	11.2	30.2
30.0	13.8	32.7

By courtesy of the Swedish Dairies Association (SMR), dept. C-lab., Malmö/Lund, Sweden.

The advantages gained through deaeration are:
• Improved working conditions for the homogeniser.
• Less risk of fouling during heat treatment.
• Improved stability and viscosity of the yoghurt.
• Removal of volatile off-flavours (deodorisation).

Homogenisation

The main motives for homogenising milk intended for cultured milk production are to prevent creaming during the incubation period and to assure uniform distribution of the milk fat.

Homogenisation also improves the stability and consistency of cultured milks, even those with low fat contents.

Homogenisation with subsequent heating at high temperature, usually 90 – 95°C for about 5 minutes, has a very good influence on the viscosity.

Table 11.1 illustrates the dual influence on the viscosity of a cultured milk (Swedish filmjölk; 3% fat and about 8.7% MSNF) when it is pre-treated at various homogenisation pressures and heating temperatures. The homogenisation temperature is 60°C in all cases.

The viscosity is measured with a simple viscosimeter (SMR viscosimeter) at 20°C, and the result is given in seconds for 100 ml of product to pass a nozzle of a certain diameter. Figure 11.8 shows a viscosimeter provided with exchangable nozzles, each of a diameter of between 2 and 6 mm.

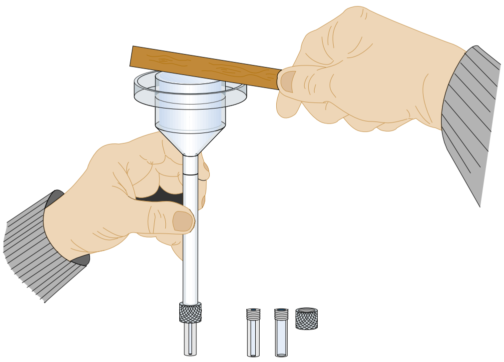


Fig 11.8 *The SMR viscosimeter.*

The viscosity of full-stream homogenised milk runs parallel to the homogenisation pressure regardless of whether it has been subjected to ordinary heat treatment or not. The table also shows that high-temperature heat treatment makes the product more viscous.

As a general recommendation, the milk should be homogenised at 20 – 25 MPa and 65 – 70°C to obtain optimum physical properties in the product. Homogenisation is frequently utilised even in production of low-fat cultured milks.

The question of single or double stage homogenisation is sometimes discussed. Generally speaking, this is a matter of the design of the homogenisation system and of the homogeniser head in particular.

Heat treatment

The milk is heat treated before being inoculated with the starter in order to:
- improve the properties of the milk as a substrate for the bacteria culture.
- ensure that the coagulum of the finished yoghurt will be firm.
- reduce the risk of whey separation in the end product.

Optimum results are achieved by heat treatment at 90 – 95°C and a holding time of about 5 minutes. That temperature/time combination denatures about 70 – 80% of the whey proteins. In particular the β-lactoglobulin, which is the principal whey protein, interacts with the κ-casein, thereby helping to give the yoghurt a stable "body".

UHT treatment and sterilisation of milk intended for culturing do not, however, have the same favourable influence on viscosity, for reasons not yet fully understood.

Choice of culture

Culture laboratories now use advanced techniques to produce customised yoghurt cultures to satisfy specific flavour and viscosity requirements. Some examples of end-product properties that can be achieved are:
- High viscosity with low acetaldehyde content and a fairly high final pH.
- Low viscosity and medium acetaldehyde content, suitable for drinking yoghurt, etc.

Culture preparation

The handling of the starter for production of yoghurt (and all other cultured milks) demands maximum precision and hygiene. The basic methods of traditional culture preparation and new trends are discussed in chapter 10, "Cultures and starter manufacture".

However, it should once again be emphasised that concentrated, frozen and freeze-dried cultures are now avaible on the market and are being more and more widely used. This saves the need to invest in a separate culture room – a saving which must be offset against subscription costs and the cost of providing adequate storage facilities for the cultures. The greatest advantage, however, is that direct inoculation of milk with a concentrated culture minimises the risk of contamination, as the intermediate stages of propagation are excluded.

Plant design

The coagulum formed during fermentation is sensitive to mechanical treatment. This makes the selection and dimensioning of pipes, valves, pumps, coolers, etc. very important.

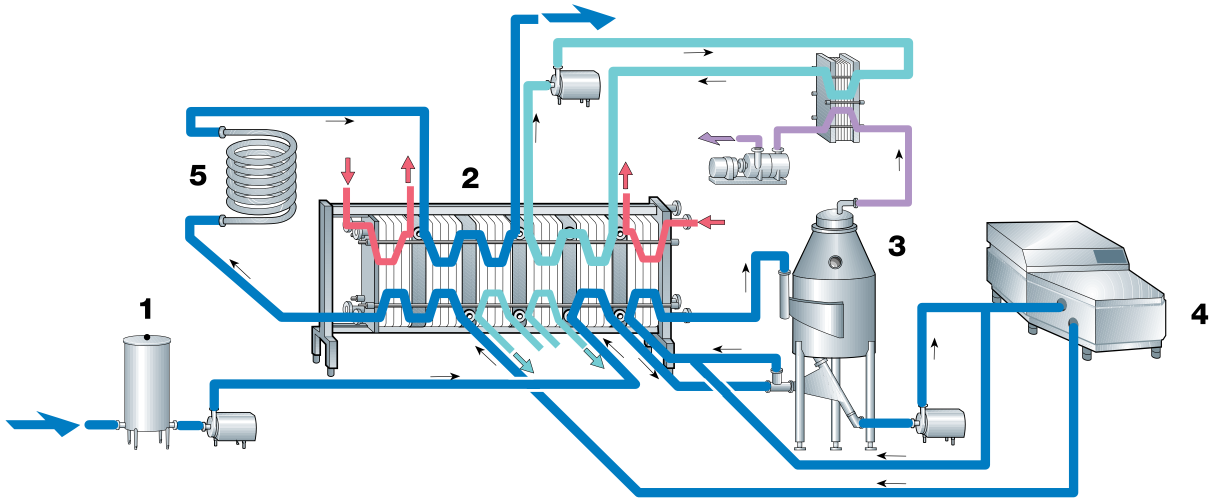


Fig. 11.9 *General pre-treatment for cultured milk products.*

1 Balance tank
2 Plate heat exchanger
3 Evaporator
4 Homogeniser
5 Holding tube

Milk/yoghurt
Cooling media
Heating media
Vapour

Production lines

The pretreatment of the milk is the same, regardless of whether set or stirred yoghurt is to be produced. It includes standardisation of the fat and DM contents, heat treatment and homogenisation.

Figure 11.9 shows an example of the design of a process line for yoghurt production. The milk storage tanks, from which the milk is pumped to the process line, are not shown in the figure. It is assumed that the milk has been standardised to the required fat content before entering the line. In the example, standardisation of the DM content takes place in an evaporator in the process line. If the DM content is adjusted by addition of milk powder, the equipment used is similar to that described under "Recombined milk" in chapter 18. The milk, increased in DM by milk powder addition, should preferably be deaerated to reduce the risk of whey separation.

Any additives, such as stabilisers, vitamins, etc., can be metered into the milk before the heat treatment. From the balance tank the milk is pumped to heat exchanger (2), where it is first preheated regeneratively to about 70°C and then heated to 90°C in the second section.

Evaporation

From the heat exchanger the hot milk flows to vacuum vessel (3), where 10 – 20% of the water in the milk is evaporated. The proportion depends on the required DM content of the milk. If 10 – 20% of the milk is evaporated, the total DM content will be increased by about 1.5 – 3.0%. The degree of evaporation is controlled by the temperature of the milk at the inlet to the vacuum vessel, the circulation rate through the vessel and the vacuum in the vessel. Some of the water evaporated from the product is used to preheat the incoming milk. This improves the thermal economy of the plant.

A certain amount of milk must be recirculated through the vacuum vessel in order to obtain the desired degree of evaporation. Each passage evaporates 3 – 4% water, so to obtain 15% evaporation, the recirculated flow must be four to five times the capacity of the pasteuriser. The milk temperature drops from 90°C to about 70°C during evaporation.

The evaporation equipment described is designed for capacities up to about 8 000 l/h. Larger evaporators of the falling-film type are used for higher capacities – up to 30 000 l/h.

Evaporation of 10 – 20% of the milk volume increases the DM content in the milk by 1.5 – 3.0%.

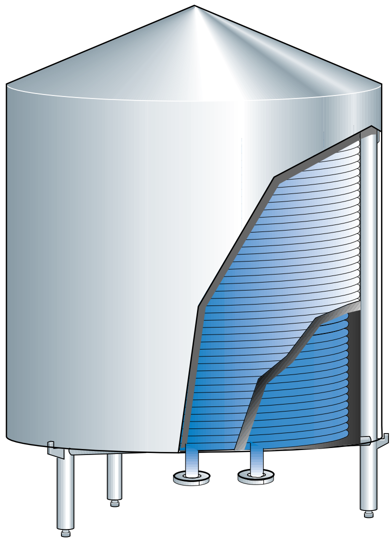


Fig. 11.10 *Tubular holding section.*

Homogenisation

After evaporation the milk continues to homogeniser (4) and is homogenised at a pressure of approx. 20 – 25 MPa (200 – 250 bar).

Pasteurisation

The homogenised milk flows back through the regenerative section to the pasteurisation section of heat exchanger (2) and is reheated to 90 – 95°C. The milk then flows to a holding section dimensioned for a holding time of 5 minutes.

Other time/temperature programs can be used. The tubular holding section shown in figure 11.10 offers a holding efficiency of 90 – 95%, which is appreciably higher than when one holding tank is integrated in a continuously operated plant.

The procedure in plants with a holding tank is as follows:

The holding tank is by-passed during the startup period until all parameters have been reached and all water has been displaced from the plant. Production is then started by routing the hot milk to the holding tank, whose outlet valve remains closed for 30 minutes. The milk enters the tank at the top.

When the 30 minutes have passed, the outlet valve is opened and the hot milk is pumped to the downstream side of the pasteuriser at the same rate as the filling rate. From here on the process is continuous. This system offers a holding efficiency of 12 – 15%, say 13%, i.e. an average holding time of 13x30/100 = 3.9 minutes, approx. 4 minutes. The arrangement with one holding tank creates some plant design problems because milk flows only on the upstream side of the plates during the first half hour of filling, resulting in disturbance of the temperature program. However, the problem can be overcome with a more complicated plant solution.

Cooling the milk

After pasteurisation the milk is cooled, first in the regenerative section and then with water, to the desired inoculation temperature, typically 40 – 45°C or, if set yoghurt is to be produced and the pre-treatment capacity does not match the packing capacity, to a temperature below 10°C, preferably 5°C.

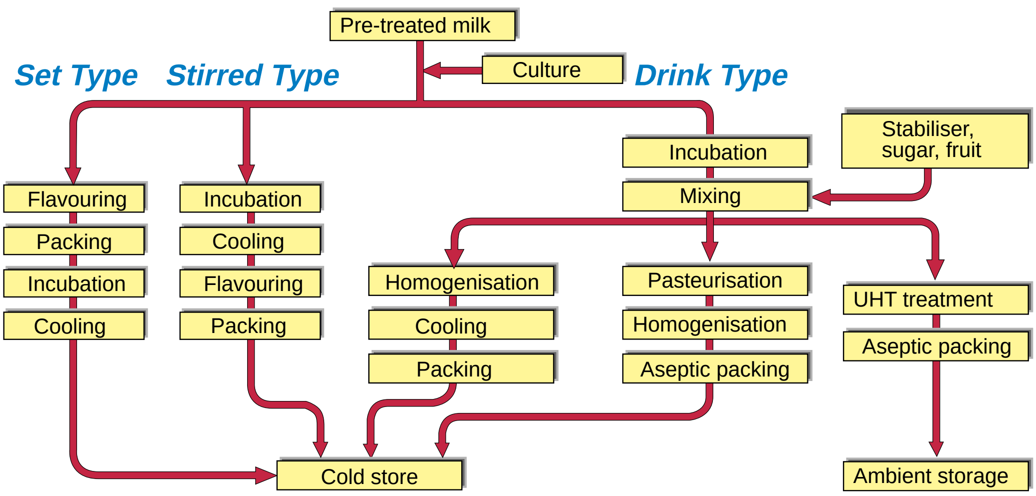


Fig. 11.11 *Block diagram showing production steps for set, stirred and drinking yoghurt.*

Design of the yoghurt plant

When the yoghurt milk has been pretreated and cooled to inoculation temperature, the procedure for further treatment depends on whether set, stirred, drink, frozen or concentrated yoghurt is to be produced. The block diagrams in figures 11.11 – 11.13 show the various production stages for each process.

The quality of the yoghurt in terms of texture and flavour depends on the design of the plant, the treatment of the milk and the treatment of the product. Modern plants are designed to satisfy demands for high production, continuous treatment and high quality. The level of automation varies, and complete CIP systems are normally integrated into the plants.

The level of automation is usually high in large-scale production. Excessive mechanical treatment of the product must be avoided, as it may cause product defects such as thin consistency and whey separation. The total volume of treatment to which the product is subjected must be taken into consideration when the plant is designed. The choice of suitable equipment and the matching and optimisation of the plant are consequently a question of achieving a suitable balance between cost and quality.

In modern plants, stirred and set types of yoghurt are often produced concurrently. In the production of set yoghurt the product flow is continuously controlled from the point where the milk is accepted in the pretreatment section to the packaging of the product. In the production of stirred yoghurt, the pretreatment of the milk is continuous up to the point at which it is pumped into the incubation tanks, to which the bulk starter is added. The continuity is interrupted by the time-consuming incubation, which must be free from any physical disturbance.

Stirred yoghurt

A typical plant for continuous production of a relatively large volume of stirred yoghurt is shown in figure 11.14.

The pretreated milk, cooled to incubation temperature, is pumped to the

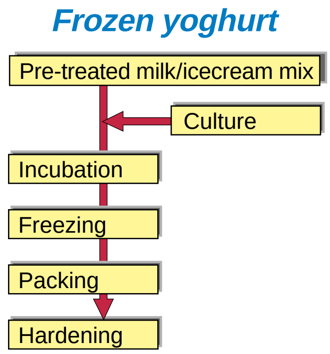


Fig. 11.12 *Block diagram showing production steps for frozen yoghurt.*

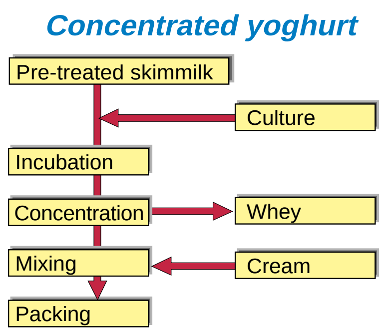
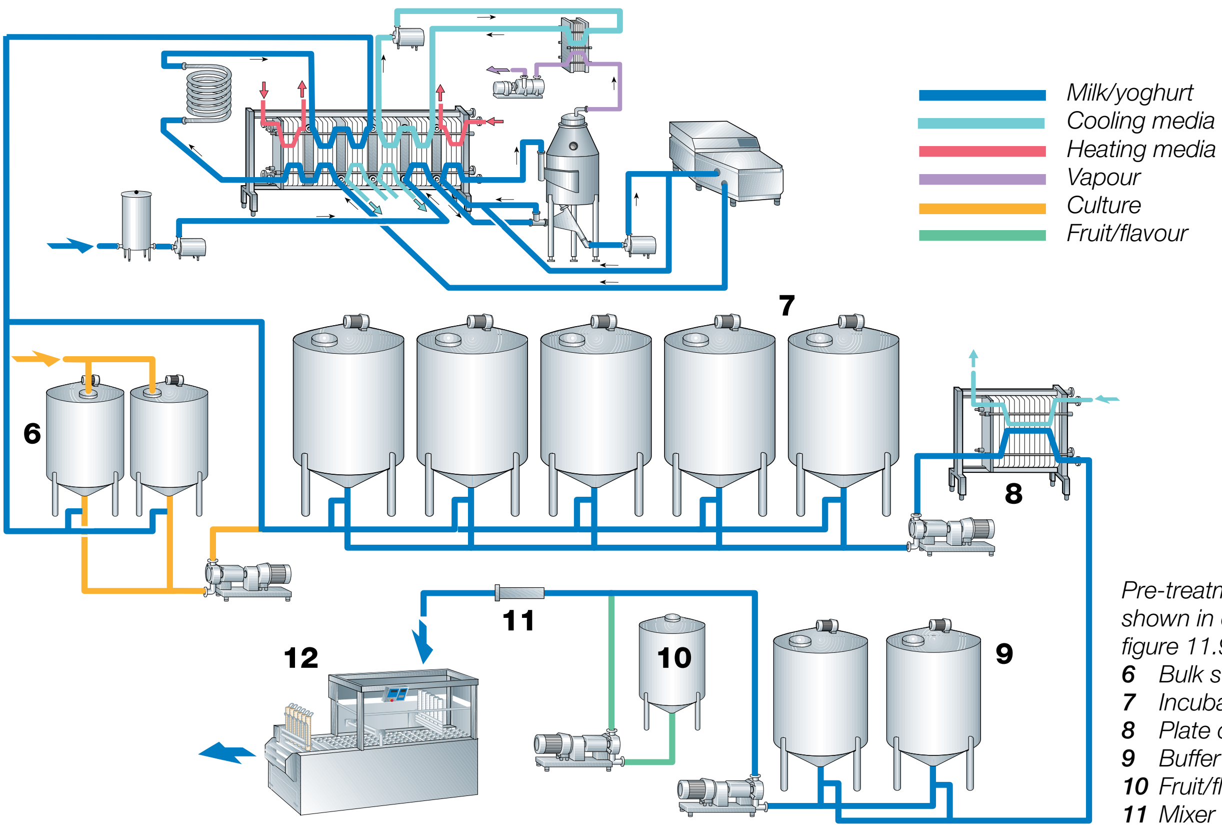


Fig. 11.13 *Block diagram showing production steps for concentrated yoghurt.*



Pre-treatment is shown in detail in figure 11.9

6 Bulk starter tanks
7 Incubation tanks
8 Plate cooler
9 Buffer tanks
10 Fruit/flavour
11 Mixer
12 Packaging

Fig. 11.14 *Production line for stirred yoghurt.*

incubation tanks (7) in succession. Simultaneously a preset volume of bulk starter (6) is dosed into the milk stream. After a tank has been filled, agitation commences and continues for a short time to assure uniform distribution of the starter culture.

The incubation tanks are insulated to ensure that the temperature remains constant during the incubation period. The tanks can be fitted with pH meters to check the development of acidity.

In typical production of stirred yoghurt the incubation period is 2.5 to 3 hours at 42 – 43°C when the ordinary type of bulk starter (2.5 – 3% inoculum) is utilised. The short incubation time indicates that the multiplication (generation) period is fast. For typical yoghurt bacteria the generation period is some 20 – 30 minutes. To attain optimum quality conditions, cooling to 15 – 22°C (from 42 – 43°C) should be accomplished within 30 minutes after the ideal pH-value has been reached to stop further developement of bacteria. (Where concentrated, frozen or freeze-dried cultures are added directly to the yoghurt incubation tanks, a longer incubation time, 4 – 6 hours at 43°C, is necessary on account of the longer lag phase).

Cooling the coagulum

In the final stage of incubation, when the required pH (normally about 4.2 – 4.5) has been reached, the yoghurt must be cooled to 15 – 22°C. This stops temporarily any further increase in acidity. At the same time the coagulum must be subjected to gentle mechanical treatment so that the final product will have the correct consistency.

Cooling takes place in a plate heat exchanger (8) with special platage. This ensures gentle mechanical treatment of the product. The capacities of pump and cooler are dimensioned to empty a tank in 20 – 30 minutes in order to maintain a uniform product quality. If cultures with other fermentation curves are utilised, which may have an influence on the incubation time, the cooling time should be adapted in view of that.

The cooled yoghurt is pumped to buffer tanks (9) before being routed to the filling machine(s) (12).

Flavouring

After cooling to 15 – 22°C, the yoghurt is ready for packing. Fruit and various flavourings can be added (10) to the yoghurt when it is transferred from the buffer tanks to the filling machines. This is done continuously with a variable-speed metering pump which feeds the ingredients into the yoghurt in the fruit blending unit shown in figure 11.15. The blending unit is static and hygienically designed to guarantee that the fruit is thoroughly mixed into the yoghurt. The fruit metering pump and the yoghurt feed pump operate synchronously.

The fruit additives can be:

- sweet, normally 50- 55% ordinary sugar content;
- natural, unsweetened.

The fruit should be as homogeneous as possible. A thickener in the form of pectin can be added. The proportion of pectin is hardly ever higher than 0.5%, which corresponds to 0.05 – 0.005% of pectin in the end product.

Proper heat treatment is an extremely important stage in the pretreatment of fruit additives. Scraped-surface heat exchangers, or tanks with scraper units, can be used for adequate pasteurisation of whole berries or fruit with solid particles. The temperature program should be such that all vegetative micro-organisms are inactivated without impairing the taste and texture of the fruit. Continuous production, with rapid heating and cooling, is therefore important with regard to product quality and economic aspects. Following the heat treatment it is important that the fruit is packed in sterilised containers under aseptic conditions. Deterioration of cultured milk products is too often caused by reinfection from inadequately treated fruit.

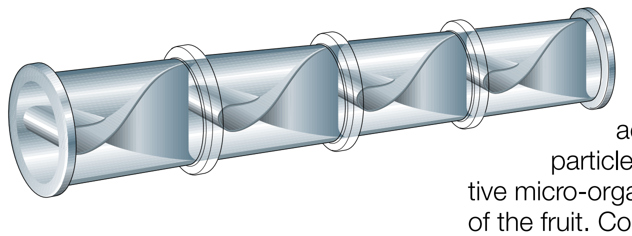


Fig. 11.15 *Fruit mixer built into the pipe.*

Packing
Various types of filling machines are used to pack yoghurt. The sizes of the packages vary from one market to another. In general the total packing capacity should match the capacity of the pasteurisation plant, so as to obtain optimal running conditions for the plant as a whole.

Plant design
As mentioned, the plant design is one important factor affecting the quality of the yoghurt and, of course, all other cultured products.

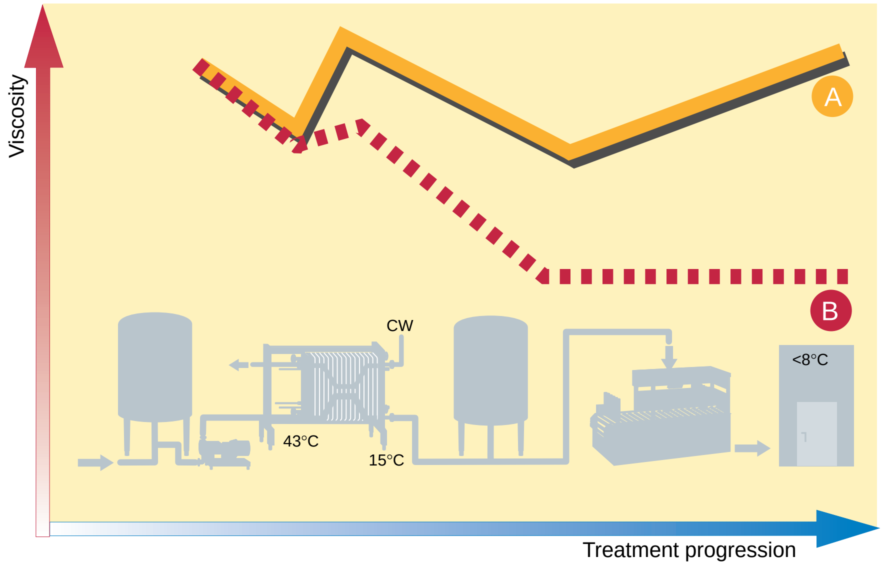


Fig.11.16 *Viscosity development of stirred yoghurt during cooling, packing and cold storage.*
A *Optimum plant design* ***B*** *Badly designed plant*

Figure 11.16 shows curves for the development of viscosity in stirred yoghurt from the moment it leaves the incubation tank, via packing and up to about 10 hours in cold storage.

Curve A represents the ideal situation when all operations that influence the structure and viscocity are optimised.

It is inevitable that the product will become less viscous while being treated, since yoghurt belongs to the class of products with thixotropic flow behaviour, but if all parameters and equipment are fully optimised the viscocity will be almost fully regenerated and the tendency to syneresis minimised.

Curve B shows the result when the product has been maltreated en route from the incubation tank up to packaging and cold storage.

Set yoghurt
In order to reduce installation costs it is possible to use the same plant for production of both stirred and set yoghurt. The pre-treatment of the milk intended for either product is identical up to cooling down to incubation temperature. Figure 11.17 shows how this kind of production can be arranged. The starter is metered into the stream of milk as it is pumped from an intermediate storage tank to the filling machine.

Flavouring/Packaging
Flavouring can be continuously metered into the milk stream prior to the filling machine. If fruit or additives with particles should be added these have to be dosed into the packages or cups first before they are filled with inoculated milk. It is, however, important to remember that additives with low pH have a negative influence on fermentation.

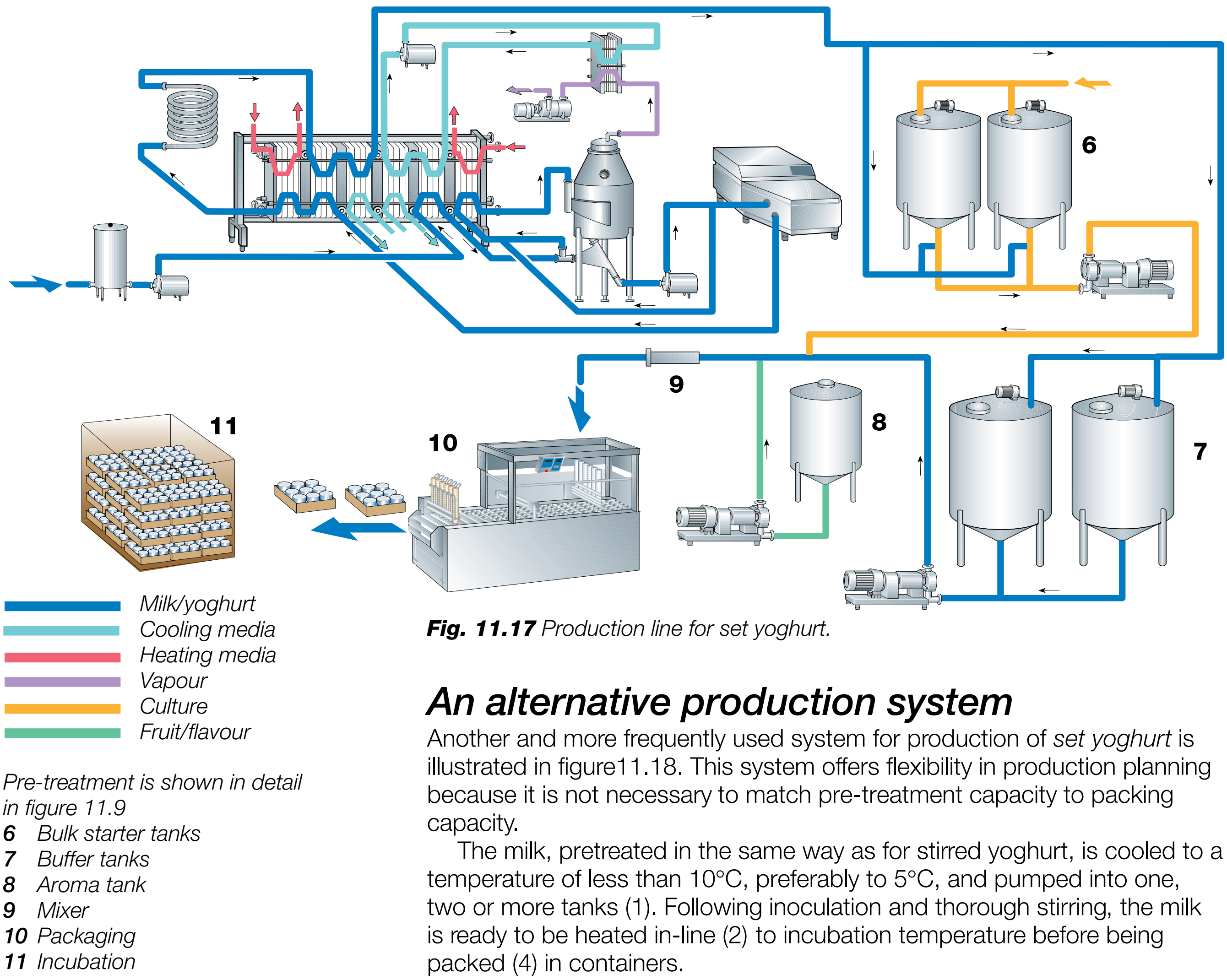


Fig. 11.17 *Production line for set yoghurt.*

An alternative production system

Another and more frequently used system for production of *set yoghurt* is illustrated in figure11.18. This system offers flexibility in production planning because it is not necessary to match pre-treatment capacity to packing capacity.

The milk, pretreated in the same way as for stirred yoghurt, is cooled to a temperature of less than 10°C, preferably to 5°C, and pumped into one, two or more tanks (1). Following inoculation and thorough stirring, the milk is ready to be heated in-line (2) to incubation temperature before being packed (4) in containers.

Bulk starter culture can also be added in-line prior to heating to incubation temperature.

Flavouring/Packing

The peviously described flavouring (3) and packing process is also applicable to the alternative system.

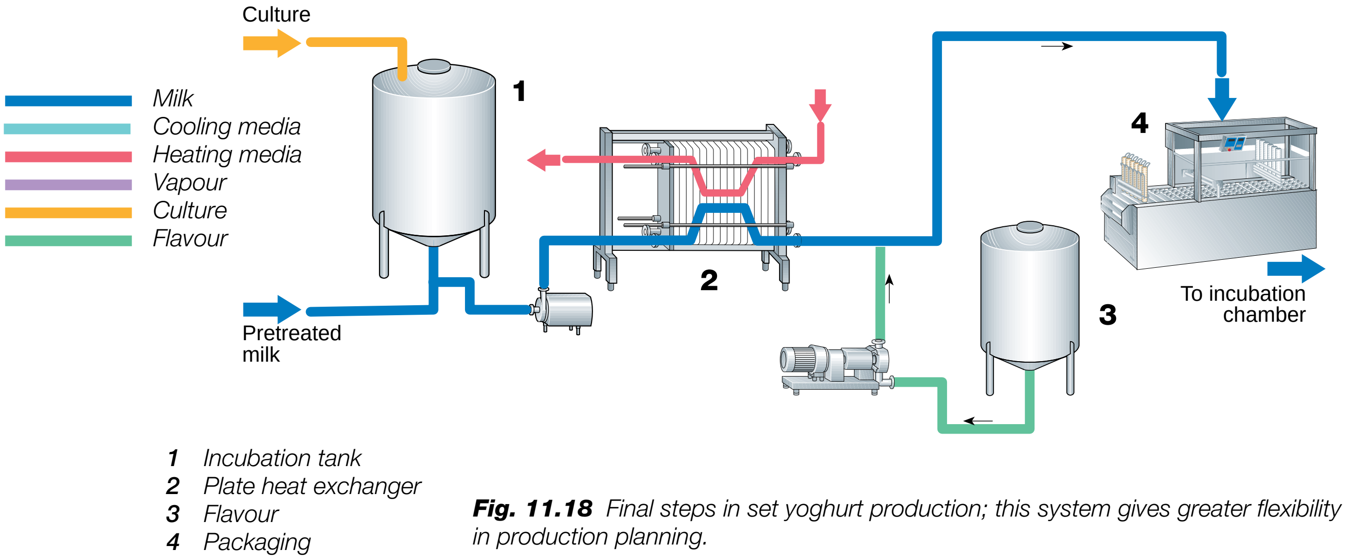


Fig. 11.18 *Final steps in set yoghurt production; this system gives greater flexibility in production planning.*

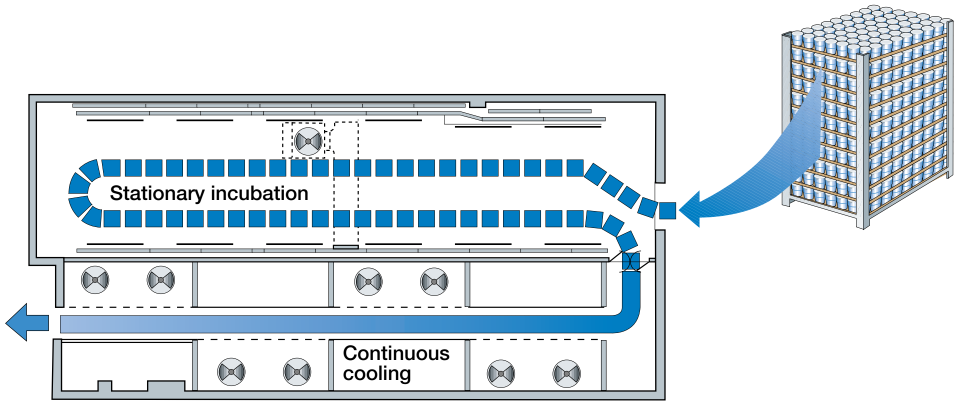


Fig. 11.19 *Combined incubation room and cooling tunnel.*

Incubation and cooling

Following packaging the packages, after crating and palletising, are trucked into either of two systems for incubation and subsequent cooling viz.:

- Combined incubation/cooling chamber when the pallets are stationary through both incubation and cooling before being trucked to the final chilling store.
- An incubation room able to accomodate a large number of filled pallets. After adequate incubation the pallets are trucked to a conveyor passing through the cooling sections enclosed in a tunnel. This system offers "continuous" cooling and is illustrated in figure 11.19.

Incubation

The filled packages/containers are placed in crates of open design and at a certain distance from each other so that the circulating warm/cold air for the incubation and cooling room or chamber can reach every individual container. The crates are normally stacked on pallets, which are then trucked into the incubation room. This ensures uniform quality, provided that the temperature is accurately controlled.

Cooling

When the empirically determined optimum pH (typically 4.5) is reached, it is time to start cooling. The normal target temperature is 18 – 20°C; it is important to stop further growth quickly, which means that a temperature of about 35°C should be reached within 30 minutes, and 18 – 20°C after another 30 – 40 minutes.

Final cooling, normally down to 5°C, takes place in the chill store, where the products are held to await distribution.

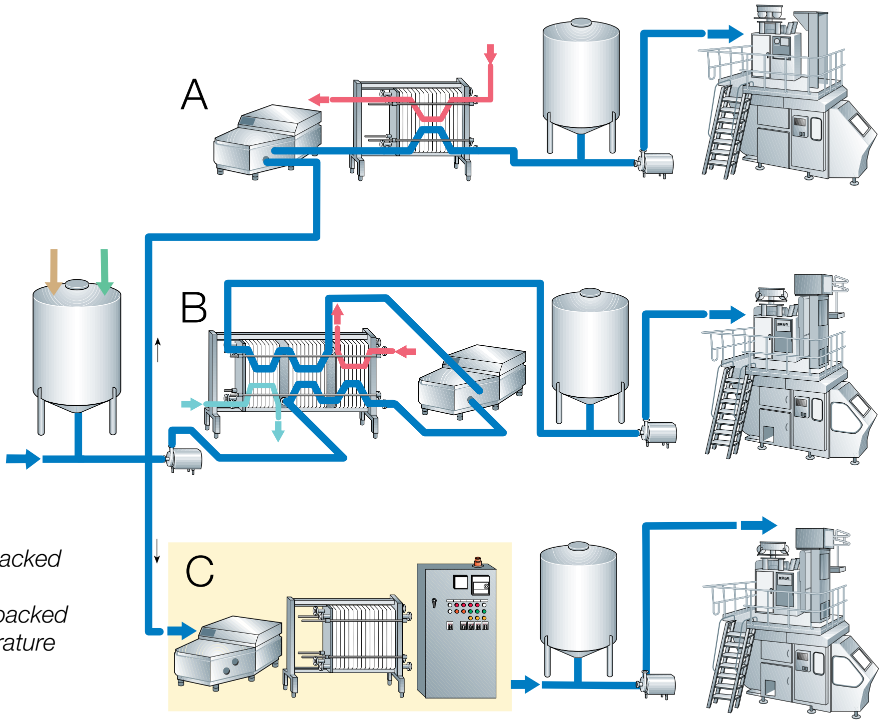
Cooling efficiency depends on the size of the individual package, the design and material of the packages, the depth of the crate stack, the spacing between individual packages in each crate, and the design of the crates.

At a depth of one (1) metre, for example, the free cross section of the stack for air-flow must be not less than 25% of the total area. A smaller free cross section will require higher airflows, which also means higher energy consumption.

The pallets (crates) are stationary during incubation. They are placed in the incubation room/chamber in such a way as to facilitate first in/first out handling. In a typical incubation period of 3 – 3.5 hours, it is very important that the product is not exposed to any mechanical disturbance during the last 2 – 2.5 hours, when it is most sensitive to the risk of whey separation.

The cooling capacity should be adequate to achieve the above mentioned temperature program. As a guide, it may be mentioned that the total cooling time is about 65 – 70 minutes for small packages (0.175 – 0.2 kg sizes) and about 80 – 90 minutes for large packages (0.5 kg size).

Eventually, regardless of the type of incubation/cooling chamber, the set yoghurt is cooled to about 5°C in the chill store.



A *Homogenised and cooled*
Shelf life: 2 – 3 weeks, refrigerated
B *Homogenised, pasteurised, aseptically packed*
Shelf life: 1 – 2 months, refrigerated
C *Homogenised, UHT treated, aseptically packed*
Shelf life: several months at room temperature

Yoghurt
Cooling media
Heating media
Flavour
Stabiliser

Fig. 11.20 *Process alternatives for drinking yoghurt.*

Drinking yoghurt

A low-viscosity drinkable yoghurt, normally with a low fat content, is popular in many countries. Three process alternatives are illustrated in figure 11.20.

The yoghurt intended for production of drinking yoghurt is produced in the ordinary way. Following stirring up and cooling to about 18 – 20°C the yoghurt is transferred to the buffer tank prior to the process alternatives in the figure. Stabiliser and flavours are mixed with the yoghurt in the tank The yoghurt mix can then be treated in different ways, depending on the required shelf life of the product.

Long-life yoghurt

Because of the tendency towards larger and more centralised production units, the markets are becoming geographically larger and transport distances longer. In some cases the sales district may be so large that only one delivery per week is economically justifiable. This, in turn, necessitates methods which extend the shelf life of the product beyond normal. In some countries it is difficult to maintain the integrity of the cooling chain. There is therefore a demand for a sterilised yoghurt that can be stored at room temperature.

The shelf life of cultured milk products can be extended in two ways:

- production and packing under aseptic conditions;
- heat treatment of the finished product, either immediately before packing or in the package.

Production under aseptic conditions

In aseptic production, measures are taken to prevent the yoghurt from being infected by yeast and moulds. These micro-organisms would destroy the product, as they can survive and multiply in an acid environment and can cause off-flavours and whey separation. The prime measure is thorough cleaning and sterilisation of all surfaces in contact with the product. The special feature of aseptic production is, however, that it takes place under aseptic conditions; using aseptic tanks which are permanently pressurised with sterile air, remote controlled aseptic valves, aseptic metering devices for fruit and aseptic filling machines. Infection by airborne micro-organisms can then be prevented. This extends the shelf life of the product significantly.

"Clean Room" production conditions

Hygenic conditions must be maintained in all food industries, not only in the equipment coming in direct contact with the product but also in the premises where production takes place.

A system based on filtration of the air through "absolute filters", as shown in figure 11.21, can be installed to clean the air in processing rooms, tanks, etc. to a high standard of purity.

A system serving four tanks consists of:

- one fan delivering about 400 m^3/h of filtered air, i.e. 100 m^3/h per tank.
- one "absolute filter" capable of trapping particles larger than 0.3 microns; this will capture most micro-organisms, as the average diameters of cocci, bacilli and fungi (yeasts and moulds) are 0.9, 0.25 – 10 and 3 – 15 microns respectively.
- one casing for the filter
- one basic duct
- four connecting pipes
- valves and manometers

Each system or tank to be supplied with air is equipped with an extra pipe for the air and a safety system to prevent the tank from imploding as a result of the vacuum created by the drop in temperature after cleaning.

Air velocity is approx. 0.5 m/s and the tank is positively pressurised to approx. 5 – 10 m water gauge, corresponding to about 0.05 – 0.1 bar.

The filter is normally placed in the process room, with the result that all contaminant particles in the ambient air will eventually be filtered out, thereby creating "Clean Room" conditions.

Similar systems are used in bacterological laboratories, hospital operating theatres and pharmaceutical factories.

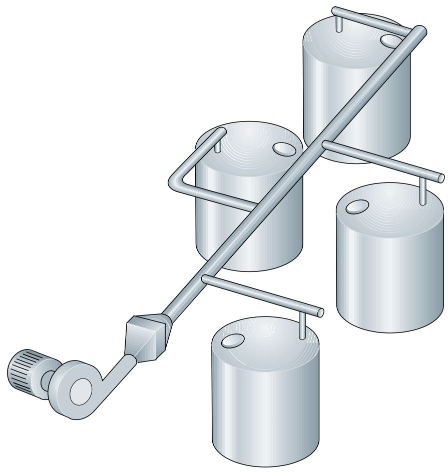


Fig. 11.21 *An air filtration system for the "Clean Room" concept.*

Heat treatment of yoghurt

Heat treatment of yoghurt prolongs its shelf life by:

- inactivating the starter bacteria and their enzymes
- inactivating contaminants such as yeasts and moulds

In production of stirred yoghurt, the coagulum from the incubation tanks is heated to 72 – 75°C in a heat exchanger, with a holding time of a few seconds before being cooled. The product should then be packed in an aseptic filling machine to prevent reinfection.

Set yoghurt can be heat-treated at 72 – 75°C for 5 – 10 minutes in the packages, in special pasteurising chambers. In both cases a stabiliser is added prior to heating.

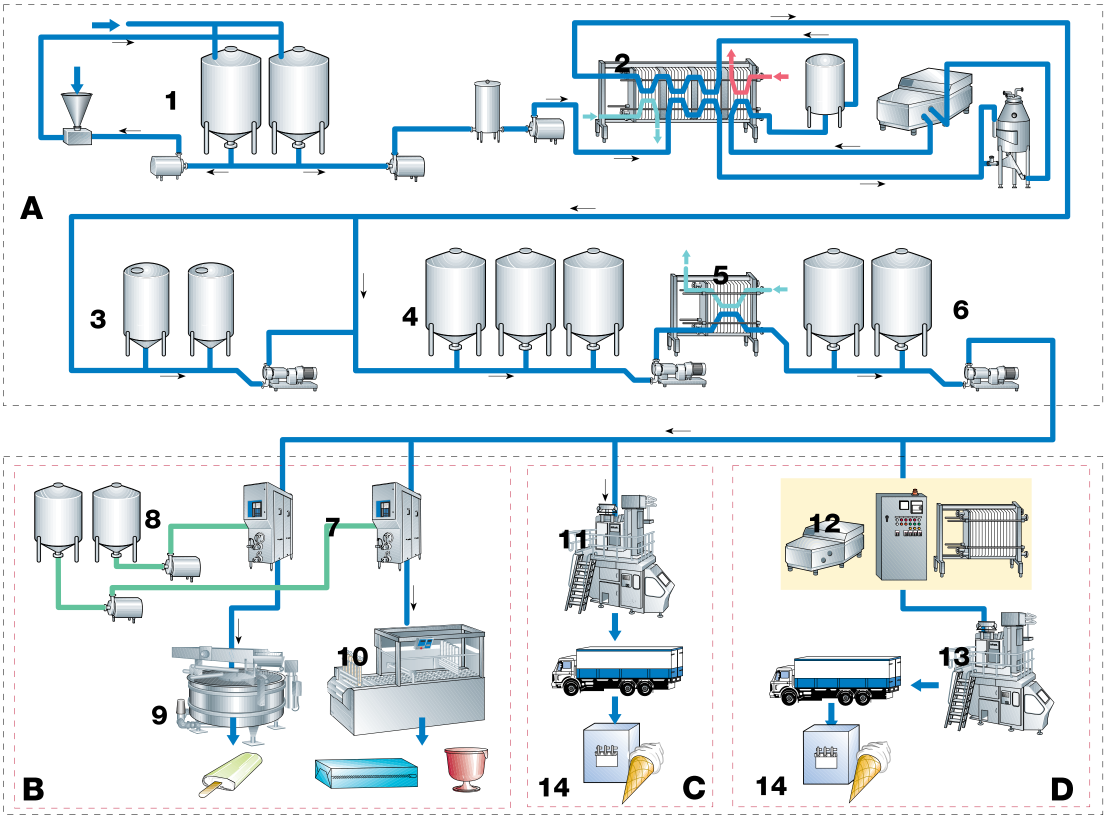
Heating to 70 – 75°C kills all the virulent micro-organisms in the yoghurt.

In many countries yoghurt is defined as a product in which the microbiological flora is kept alive right up to the instant of consumption. *This means that heat treatment of the end product is prohibited.* In some countries the use of *stabilisers* is forbidden by law or is only permitted to a limited extent.

Frozen yoghurt

Frozen yoghurt can be manufactured in two ways. Either yoghurt is mixed with ice cream mix or a yoghurt mix is fermented, before further processing. Frozen yoghurt can be divided into soft-served and hard frozen types. The mix intended for soft-served yoghurt differs somewhat from that of the hard frozen type. Typical recipes are:

Ingredients, %	Soft-served	Hard frozen
Fat	4	6
Sugar	11 – 14	12 – 15
MSNF	10 – 11	12
Stabiliser, emulsifier	0.85	0.85
Water	71	66



A Yoghurt manufacture
B Hard ice cream
C Soft ice cream mix
D Long life soft ice cream mix

1 Mixing tanks
2 Pasteuriser
3 Bulk starter tanks
4 Incubation tanks
5 Cooler
6 Buffer tanks
7 Ice cream freezer
8 Aroma tanks
9 Bar freezer
10 Cup/cone filler
11 Packaging
12 UHT treatment
13 Aseptic packaging
14 Soft-ice machine at the retailer

Product
Cooling media
Heating media
Aroma

Fig. 11.22 *Alternatives for frozen yoghurt production.*

Fig. 11.23 *A continuous ice cream freezer.*

Production of yoghurt mix

The mix, supplemented with suitable stabiliser and emulsifier, is manufactured in essentially the same manner as conventional yoghurt.

The flowchart in figure 11.22, block A, shows the process where the mixed raw materials are de-aerated and homogenised at 70°C before being pasteurised in a heat exchanger at 90°C for 5 minutes. After regenerative cooling to 43°C, the milk is transferred to incubation tanks to which the bulk starter is added.

About 4 – 6% starter is dosed into the pipeline as the milk is pumped to the incubation tanks. The incubation time of the yoghurt mix is appreciably longer than for normal yoghurt production. This is because the yoghurt mix contains much more carbohydrates than normal yoghurt. An incubation time of 7 – 8 hours is required at a saccharose content of 10 – 12% to attain the characteristic acidity of yoghurt, which occurs at pH 4.5.

When the required pH has been achieved, the yoghurt mix is cooled in a heat exchanger to stop further fermentation. Any flavouring and sugar may be added by a metering pump into a mixing device before the yoghurt is transferred to the intermediate storage tanks.

From the intermediate tanks, production can proceed along several alternative paths as in blocks B, C and D in figure 11.22:

B. The yoghurt mix is transferred direct to the ice cream freezer followed by either stick bar freezing or cup/bulk filling and continuous hardening to hard frozen yoghurt.

C. The mix for soft-served yoghurt is packed directly into disposable packages, such as conventional milk packs or bag-in-box. These are then distributed direct to the sales outlets for soft ice cream.

D. To produce an ice cream mix intended for soft-served yoghurt with extended shelf life, the mix can be sterilised in a UHT plant before being aseptically packed.

Hard-frozen yoghurt

As in the case of conventional ice cream, the yoghurt is pre-frozen and whipped in a continuous ice-cream freezer, figure 11.23. Whipping takes place in a nitrogenous atmosphere to avoid oxidation problems during subsequent storage. The frozen yoghurt leaves the freezer at – 8°C, which is somewhat lower than the temperature of conventional ice cream. This gives it an optimum viscosity that suits most filling machines.

Liquid fruit flavouring or sugar can be added in the freezer. Frozen yoghurt with different flavours can be produced in parallel freezers from a common yoghurt mix.

After freezing, the frozen yoghurt is packed into cones or cups or family-size packs in the same way as conventional ice cream. The packs then go into a hardening tunnel, where the temperature is reduced to – 25°C.

Frozen yoghurt bars can be frozen continuously in a regular ice cream bar freezer. Since the yoghurt is frozen directly to – 25°C, it can be transported to the cold store immediately after packaging.

Distribution

Hard-frozen yoghurt which is whipped with nitrogen can be kept in cold storage for 2 – 3 months without any adverse effects on its flavour or texture. Distribution requires an unbroken cold chain right up to the instant of consumption.

In the case of the mix for *soft-served yoghurt* (not subjected to UHT treatment), a maximum storage temperature of +6°C is recommended. This mix has a storage life of a couple of weeks. Soft-served yoghurt is consumed immediately after freezing.

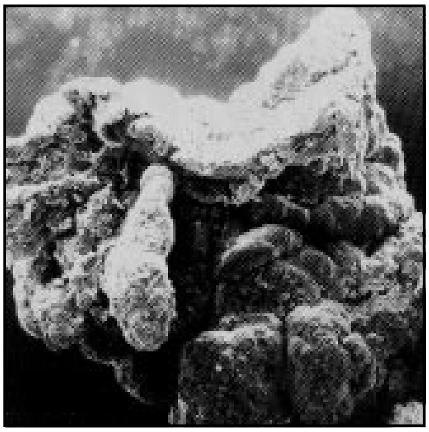


Fig. 11.24 *Kefir grain.*

Concentrated yoghurt

In concentrated yoghurt the DM of the product is increased after fermentation. Whey is drained off from the coagulum. The manufacturing principles are identical with the manufacturing of quarg, see chapter 14. The only difference is the type of cultures used. Concentrated yoghurt is known under names such as "strained" type yoghurt and Labneh.

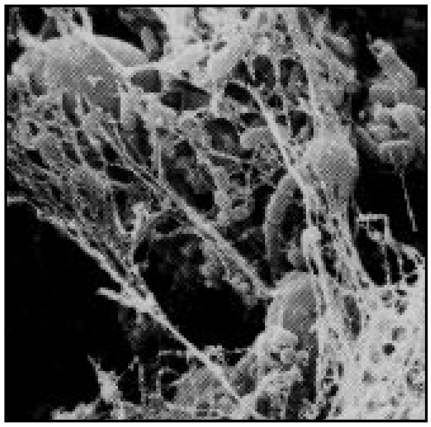


Fig. 11.25 *The micro-organisms in cultured products often live in symbiosis with each other.*

Kefir

Kefir is one of the oldest cultured milk products. It originates from the Caucasus region. The raw material is milk from goats, sheep or cows. Kefir is produced in many countries, although the largest quantity – an annual total of about 5 litres per capita – is consumed in Russia.

Kefir should be viscous and homogenous, and have a shiny surface. The taste should be fresh and acid, with a slight flavour of yeast. The pH of the product is usually 4.3 – 4.4.

A special culture, known as Kefir grain, is used for the production of Kefir. The grains consist of proteins, polysaccharides and a mixture of several types of micro-organisms, such as yeasts and aroma and lactic-acid forming bacteria. The yeasts represent about 5 – 10% of the total microflora.

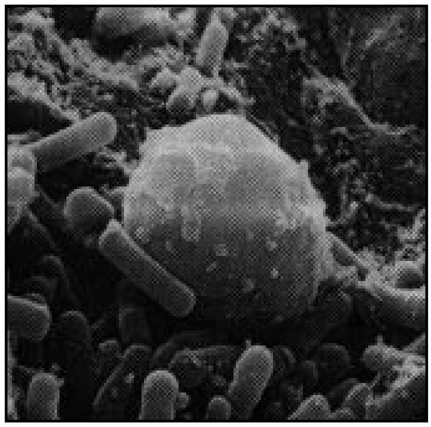


Fig. 11.26 *Yeast and lactic acid at the surface of a kefir grain, seen through an electron photomicroscope.*

The Kefir grains are yellowish in colour and about the size of a cauliflower florette, i.e. about 15 to 20 mm in diameter. The shape of the grains is irregular, see figure 11.24. They are insoluble in water and in most solvents. When steeped in milk, the grains swell and become white. During the fermentation process, the lactic-acid bacteria produce lactic acid, whereas the lactose-fermenting yeast cells produce alcohol and carbon dioxide. Some breakdown of protein also takes place in the yeast metabolism, from which Kefir derives its special yeast aroma. The contents of lactic acid, alcohol and carbon dioxide are controlled by the incubation temperature during production.

A. The yoghurt bacteria *Lactobacillus bulgaricus* (rod shaped) and *Streptococcus thermophilus* (spherical) live together.
B. Yeast and lactic acid bacteria at the surface of a kefir grain. The "ball" in the centre is a yeast fungus and the rods are different kinds of bacteria.
C. The centre of a kefir grain. Yeast and bacteria are united by a network consisting mainly of proteins and polysaccharides.

Depending on local conditions and requirements, the equipment and process variables may differ significantly from one manufacturer to another.

Raw materials

As with other cultured milk products, the quality of the raw material is of major importance. It must not contain any antibiotics or other bactericidal agents. The raw material for kefir manufacture can be milk from goats, sheep or cows.

Production of starter culture

Kefir culture is normally produced from milk of various fat contents, but skimmilk and reconstituted skimmilk, too, have lately been utilised for better control of the microbial composition of the kefir grains.

As in propagation of starter cultures for other cultured milk products, the milk substrate must be thoroughly heat-treated to inactivate bacteriophages.

Production takes place in two stages. The basic reason for this is that kefir grains are bulky and awkward to handle; relatively small volumes of mother culture are easier to control. Figure 11.27 shows the various process stages.

In the first stage the pretreated substrate is inoculated with active kefir grains. Incubation takes place at about 23°C and the proportion of grains is about 5% (1 part grains to 20 parts substrate) or 3.5% (1 part grains to 30 parts milk). The incubation time is about 20 hours; as the grains tend to sink to the bottom, intermittent stirring for about 10 – 15 minutes every 2 – 5 hours is recommended. When the desired pH value (say 4.5) has been reached, the culture is stirred before the grains are strained off from the mother culture, now also called filtrate. The strainer has holes with a diameter of 3 – 4 mm.

The grains are washed in the strainer with boiled and cooled water (sometimes skimmilk). They can then be reused to incubate a new batch of mother culture. The microbial population grows by about 10% per week during incubation, so the grains must be weighed and the surplus removed before the batch is reused.

In the second stage, the filtrate can be cooled to about 10°C if it has to be stored for a few hours before being used. Alternatively, if large quantities of kefir are going to be produced, the filtrate can be immediately inoculated into the pretreated milk intended as the substrate for the bulk starter. The dosage is 3 – 5% of the volume of the substrate. After incubation at 23°C for about 20 hours, the bulk starter is ready for inoculation into the kefir milk.

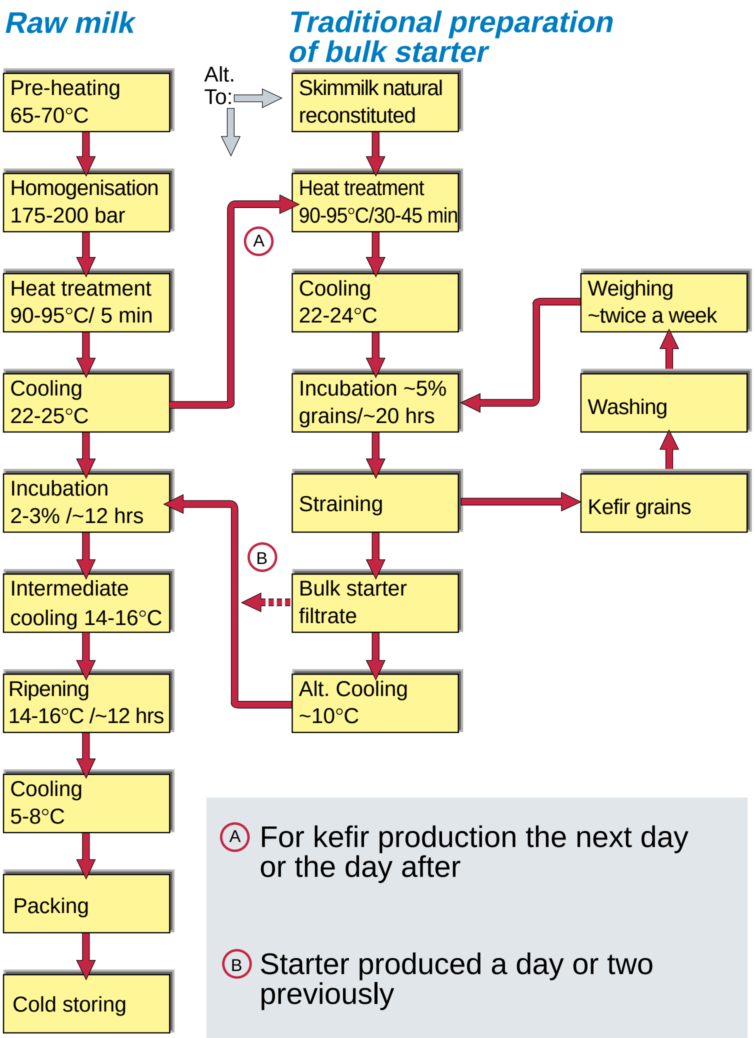


Fig. 11.27 *Typical block diagram of the various process stages in kefir production.*

Production of kefir

The process stages are much the same as for most cultured milk products. The following combination is typical for traditional production of

kefir:
- Fat standardisation (not always practised).
- Homogenisation.
- Pasteurisation and cooling to incubation temperature.
- Inoculation with starter culture (here also called filtrate).
- Incubation in two stages (this, together with the specific culture, is characteristic of kefir).
- Cooling.
- Packing.

Fat standardisation
The fat content of kefir is reported to vary between 0.5% and 6%. The raw milk is often used with its original fat content. However, fat contents of 2.5 to 3.5% are frequently specified.

Homogenisation
Following fat standardisation, if any, the milk is homogenised at about 65 – 70°C and 17.5 – 20 MPa (175 – 200 bar).

Heat treatment
The heat treatment program is the same as for yoghurt and most cultured milks: 90 – 95°C for 5 minutes.

Inoculation
Following heat treatment, the milk is cooled to inoculation temperature, usually about 23°C, after which 2 – 3% starter is added.

Incubation
The incubation period is normally divided into two stages, acidulation and ripening.

The acidulation stage
The acidulation stage lasts until a pH value of 4.5 is reached or, expressed as acidity, until 85 – 100°Th (35 – 40°SH) has developed. This takes about 12 hours. The coagulum is then stirred and pre-cooled while still in the tank. At a temperature of 14 – 16°C cooling is stopped and agitation discontinued.

The ripening stage
The typical slightly "yeasty" flavour starts to develop during the following 12 – 14 hours. Final cooling commences when the acidity has reached 110 – 120°Th (pH about 4.4).

Cooling
The product is cooled rapidly to 5 – 8°C in a heat exchanger. This stops any further reduction in pH. It is of vital importance that the product is treated gently when cooled and during subsequent packing. Mechanical agitation in pumps, pipes and filling machines must therefore be minimised. Air entrainment must also be avoided, as air increases the risk of syneresis in the product.

Alternative kefir production
As previously mentioned, the traditional method of preparing bulk starter for kefir manufacture is laborious. This, in combination with the complexity of the microflora, sometimes leads to unacceptable variations in product quality.

To overcome these problems a team at the Research Laboratory of SMR, Lund (Malmö), Sweden, has developed a freeze-dried concentrated culture that is handled in the same way as similar forms of other cultures. This type of culture has been in practical use since the mid-1980s, and the products made with it have been more uniform in quality than those made by the conventional method.

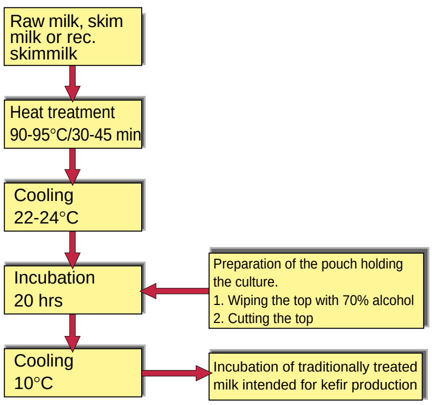


Fig. 11.28 *Bulk starter preparation for kefir with a freeze-dried culture.*

After thorough examination of kefir grains obtained from various sources, strains of bacteria and yeasts were isolated and tested for various growth characteristics, lactic acid production, aroma formation, etc. The composition of the freeze-dried culture was then chosen to obtain a balance of micro-organisms in the bulk starter and product comparable to that of traditional kefir manufactured with grains in a mother culture.

Concentrated freeze-dried kefir cultures for direct use in the milk intended for the end product are now commercially available. The block chart in figure 11.28 illustrates the processing stages.

Compared to traditional bulk starter production, the technique based on freeze-dried culture reduces the number of process stages, and with it the risk of reinfecting the culture.

Cultured cream

Cultured cream has been used for years in some countries. It forms the basis of many dishes in the same manner as yoghurt. Cultured cream can have a fat content of 10 – 12% or 20 – 30%. The starter culture contains *Str. lactis* and *Str. cremoris*, whereas *Str. diacetylactis* (D and DL cultures) and *Leuc. citrovorum* (DL and L cultures) bacteria are used for the aroma.

Cultured cream is bright, has a uniform structure and is relatively viscous. The taste should be mild and slightly acid.

Cultured cream is bright, has a uniform structure and is relatively viscous. The taste should be mild and slightly acid. Cultured cream, like other cultured products, has a limited shelf life. Strict hygiene is important to product quality.

Yeast and moulds can develop in packages which are not airtight. These micro-organisms occur mainly on the surface of the cultured cream. In the event of extended storage the lactic-acid bacteria enzymes, which break down β-lactoglobulin, become active and the cultured cream goes bitter. The cultured cream also loses its flavour because carbon dioxide and other aromatic substances diffuse through the packages.

Production

The process line for production of cultured cream includes equipment for standardisation of the fat content, homogenisation and heat treatment of the cream, and also inoculation and packing.

Homogenisation

The cream is homogenised. For cream with 10 – 12% fat the homogenisation pressure is normally 15 – 20 MPa (150 – 200 bar) at 60 – 70°C. Up to a certain point, an increase in homogenisation temperature improves the consistency.

For cream with 20 – 30% fat the homogenisation pressure should be lower, 10 – 12 MPa (100 – 120 bar), as there is not enough protein (casein) to form membranes on the enlarged total fat surface.

Heat treatment

The homogenised cream is normally heat treated for 5 minutes at 90°C. Other time/temperature combinations can be used if the homogenisation technique is carefully matched to the heat treatment.

Inoculation and packing

The pretreated cream is cooled to an inoculation temperature of 18 – 21°C. 1 – 2% of bulk starter culture is then added.

Inoculation can take place in a tank or in the packages. The fermentation time is 18 – 20 hours. When fermentation is completed, the cultured cream is cooled quickly to prevent any further pH reduction. The viscosity of the fermented cream may be very high, and it may therefore be difficult to pack. In spite of precautions, the mechanical treatment to which the cultured cream is subjected during stirring, pumping and packing also causes a slight deterioration in the consistency of the product – it will become thinner.

The cream is sometimes inoculated, packaged and fermented in the packages to avoid mechanical treatment. After inoculation of the cream and subsequent packing, the product is stored at 20°C until the acidity of the fat-free phase is about 85°Th, which takes about 16 – 18 hours. The packages are then carefully transferred to the chilled store, where they are kept for at least 24 hours at a temperature of about 6°C before distribution.

Cultured cream is often used in cooking.

Buttermilk

Buttermilk is a by-product of butter production from sweet or fermented cream.

The fat content is about 0.5%, and it contains a lot of membrane material including lecithin. The shelf life is short, as the taste of the buttermilk changes fairly quickly because of oxidation of the membrane material content. Whey separation is common in buttermilk from fermented cream, and product defects are therefore difficult to prevent.

Fermented buttermilk

Fermented buttermilk is manufactured on many markets in order to overcome problems such as off-flavours and short shelf life. The raw material can be sweet buttermilk from the manufacture of butter based on sweet cream, skimmilk or low-fat milk.

In all cases the raw material is heat treated at 90 – 95°C for about 5 minutes before being cooled to inoculation temperature. Ordinary lactic-acid bacteria are most commonly used. In some cases, when the raw material is skimmilk or low fat milk, grains of butter are also added to the product to make it look more like buttermilk.

Recent developments in cultured milk products

"Living lactic acid bacteria – vaccine of the future?"

The above headline in the Scandinavian Journal of Nutrition/Näringsforskning, Vol 37:132-137, 1993, appeared over a brief a report by Clas Lönner from a conference held in Lund, Sweden, on 29 April 1993.

For several years it has been known, at least in the northern part of Sweden, that a certain type of cultured milk called *Långfil* has been used to heal wounds and treat vaginal fungus infections. However, studies of lactic acid bacteria and their importance to health can be traced back to the beginning of the twentieth century. Elie Metchnikoff, professor at the Pasteur Institute in Paris, France, knew that many people in his Russian home district consumed a great deal of yoghurt and lived for a long time. (Professor Metchnikoff was awarded a Nobel Prize in medicine in 1908, but that was for the discovery of phagocytosis, i.e. the phenomenon that white blood corpuscles, leucocytes, "eat" bacteria that have invaded the body.)

Fig. 11.29 *Examples of milk products utilising new bacteria combinations to achieve positive effects on the intestine function are BRA and Onaka.*

Metchnikoff argued that lactobacilli ingested by consumption of yoghurt pass through the stomach and destroy putrefactive bacteria in the colon. By doing so they inhibit the production of "poisonous" waste products that cause chronic morbid alterations in the system, especially arteriosclerosis.

This theory of Metchnikoff's was plausible, but it has also been criticised on the grounds that lactobacilli cannot survive the low pH, approx 2, that prevails in the stomach. However that may be, the following fragments of information reflect the situation in the final decade of the twentieth century.

Interest in the deliberate use of lactic acid bacteria as a health-giving constituent of certain foods and forage products has snowballed in the past few years. The greatest enthusiasts claim that living lactic acid bacteria will be the 21st century's answer to the 20th century's penicillin and sulfa drugs.

The expression "functional food" is applied to foods with near-medicinal

L. acidophilus and *Bifido*-bacteria are important members of the human intestinal flora.

properties that promote health. “Food for special health use” is another term for the same thing. Japan is at present the leading country for “functional food” and has a great preventive programme of schemes to lower the costs of medical treatment.

Lactic acid bacteria have been used since time immemorial to ferment foods.

The special strains of bacteria normally used in production of yoghurt, as well as other types such as *Lactobacillus (L.) acidophilus*, *L. reuteri* (a relative newcomer), Bifido-bacteria and certain species of *Lactococcus lactis*, are among those that have been found of interest for production of functional foods.

What properties must a lactic acid bacterium have to be able to function in the intestine? The following four characteristics that are of primary importance:

- Ability to colonise and survive.
- Adhesive capacity.
- Ability to aggregate.
- Antagonistic effects.

L. acidophilus and Bifido-bacteria are important members of the human intestinal flora. The former normally predominates in the small intestine and the latter in the large intestine.

Production of these important bacteria is reduced in some people as a result of medication, stress or old age. In many people, reduced production of intestinal bacteria can cause symptoms such as swelling, indigestion and pronounced illness.

Consumption of live *L. acidophilus* and Bifido-bacteria in milk products is an ideal way to restore the balance of the intestinal flora. Apart from the possible prevention and relief of diarrhoea, literature indicates that *L. acidophilus* and Bifido-bacteria may help to:

- reduce the cholesterol level in the blood
- relieve lactose malabsorption (lactose intolerance)
- strengthen the immune system
- reduce the risk of stomach cancer.

(Ref.: “Nu-trish cultures”, Chr. Hansen’s Laboratories, Copenhagen, Denmark)

These micro-organisms can be utilised alone or in combination with other cultures, e.g. thermophilic, yoghurt or mesophilic cultures. A product called BRA milk, for example, was recently introduced on the Swedish market. The name has a double meaning: “BRA” is the Swedish word for good, and also the initials of Bifido, Reuteri and Acidophilus bacteria. This product is available in two versions: sweet and sour.

Lactic acid bacteria may thus have a great potential for promoting the health of both human beings and animals. The claimed effects, however, are by no means fully documented. It is therefore important that sufficient resources are invested in this field in the near future, both to find new interesting health effects of lactic acid bacteria and to compile scientific documentation.

The following bibliography is provided for the benefit of anyone interested in learning more about this subject:

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