Processing concentrated and fermented dairy products

Centrifuges and process lines for
strained yoghurt and soft cheeses

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Contents

1. Introduction

It was the use of separators that enabled soft cheese to be produced on a large scale. GEA has done pioneering work in both separator design and the ongoing development of production processes.

To ensure that soft cheese production is efficient and economical, GEA is still focused on the continued development of machines and process lines.

2. Terms, Definitions, Formulae

2.1 Soft cheese

Soft cheese is the protein from vat milk, precipitated by acidification or combined with proteolytic enzymes and the variety-specific quality and quantity of the serum that has not been separated. Soft cheese does not undergo a maturing process after production and, in principle, can be enjoyed immediately after being produced. Legislation stipulates pasteurization of the vat milk using a certified pasteurization process. For technological, nutritional and economic reasons, supplementary heat treatment is required to produce soft cheese.

Quark contains substantial amounts of essential amino acids. Because of the high valuable protein content, calcium and phosphorous and the low calorie content, low-fat quark for example is very important in dietary treatments. The high temperatures and corresponding holding times for the unacidified skim milk and the resulting complexing between casein and dairy proteins give the quark a high proportion of nutritionally valuable dairy proteins. This is the basis for increased yields and reduction in the specific use of skim milk when using the thermo quark process.

Fat levels	FDM	Min. dry matter	Min. protein content
Regular quark:			
Low-fat	<10 %	18 %	12 %
Quarter-fat	min. 10 %	19 %	11.3 %
Half-fat	min. 20 %	20 %	10.5 %
Three-quarter-fat	min. 30 %	22 %	9.7 %
Standard-fat	min. 40 %	24 %	8.7 %
Full-fat	min. 45 %	25 %	8.2 %
Cream	min. 50 %	27 %	8 %
Double cream	min. 60 max. 85 %	30 %	6.8 %
Cream cheese	min. 50 %	39 %	—
Double cream cheese	min. 60 max. 85 %	44 %	—

FDM = Fat in dry matter

2.2 Soft cheese preparations

These are ready-to-eat quarks and quark desserts with added flavorings such as cream, fruits, fruit products or spices etc. A foamy consistency can also be obtained by injecting nitrogen.

2.3 Baker's cheese

This is a low-fat quark primarily produced in the USA and Eastern European countries, with a dry matter of 22 – 24 percent.

2.4 Buttermilk quark

Buttermilk quark can be made from cultured or sweet buttermilk. It has valuable dietary and physiological properties with a relatively high phospholipid content. Because of the emulsifying effect of the lecithin, buttermilk quark is ideally suited for use in quark preparations.

2.5 Labaneh

This was originally a type of soft cheese that was widespread in the Middle East. The product, also known as "strained yoghurt" is produced from skim milk using a special yoghurt culture without additional rennet or any other similar enzymes.

2.6 Labneh

A type of soft cheese widespread in the Near and Middle East, produced using a special yoghurt culture and rennet. Labneh can be compared to standard-fat quark.

2.7 Mascarpone

Mascarpone is a type of soft cheese popular mainly in Southern Europe and produced from cream. It has a consistency similar to that of quark. Curdling can also be carried out using citric acid without additional rennet.

2.8 Cultures, rennet

Culture and rennet are essential for gelling of the vat milk.

Here, gelling refers to the conversion of polydispersed multi-phase systems in milk from sol to lyogel. This is linked to the precipitation of the casein, which can be achieved by a pH reduction in acidification and/or the effect of proteolytic enzymes such as rennet.

With acid coagulation, the pH value is reduced due to lactic acid formation by the cultures used from the lactose substrate into the iso-electric range of the casein. As a consequence of the charge equalization that occurs on the surface, the electrical neutrality of the hydration water releases the micelles, the particles are no longer held in suspension and the previously equally charged particles no longer repel each other. Mass attraction and inter-molecular forces take effect and the casein coagulates.

Rennet coagulation represents a different mechanism, which can be divided into several phases. A protective colloid, glycomacropeptide, which carries charge and thus hydration water, is enzymatically cleaved from the kappa-casein fraction. The micelles can aggregate and are bridged by calcium ions at the remaining calcium-sensitive interfaces.

As well as calf rennet, other animal and vegetable enzymes are used, as well as enzymes biotechnologically created from microorganisms, known as rennet alternatives.

Gelling for production of standard quark is carried out using culture to acidify the milk. At the same time, this acidification gives the quark its distinctive taste, depending on the culture used. The usual optional addition of supplementary rennet results in a firmer gel. This enables the vat milk to be separated more effectively and more efficiently after acidification.

The special cultures raised, known as starter cultures, are subdivided into single-strain cultures, multi-strain cultures and mixed-strain cultures. Instead of the lactic starters bred by the dairy itself that were generally used in the past, ready-made starter concentrates, deep-frozen concentrates or lyophilisates are increasingly being used today. To ensure a fault-free process, it is important to use weak or anaerogenic cultures.

O cultures:	Lactococci that do not break down citrates, acidification only, no flavoring
D cultures:	In addition to the acidifiers, contain Lactococcus lactis, subsp. lactis for flavoring
L cultures:	In addition to the acidifiers, contain Leuconostoc for flavoring
DL cultures:	Contain both types of flavoring

The required quantities of cultures and rennet that need to be added to vat milk, are based on the relevant process used. The following example outlines the use of culture in the production of standard quark using the thermo process.

The cultures used in the production of thermo quark must meet the following requirements:

- Acidification of product milk to pH 4.55 +/- 0.05 in the same periode (e.g. 16 h at 28 °C)
- Low additional acidification during shelf life
- Formation of the typical quark aroma of a mesophilic mixed culture with only moderate CO_2 development
- Optimum composition to provide the desired sensory experience and consistency
- Constant end product properties during shelf life

In addition to the types of bacteria that are typical for mesophilic mixed cultures, such as:

- Lactococcus lactis, subsp. cremoris
- Lactococcus lactis, subsp. lactis
- Lactococcus lactis, subsp. cremoris biovar, diacetylactis
- Leuconostoc mesenteroides, subsp. cremoris

the probiotic thermophilic Lactobacillus acidophilus and Bifidobacterium bifidum can also be used. In many works, these are described as nutritionally valuable bacteria. In standard quark, they have a positive influence on consistency and taste.

With Lactobacillus acidophilus, approx. 10 percent of the bacterial count in the coagulum can be expected to be obtained in the quark after thermization.

In addition to the typical soft cheese cultures, yoghurt cultures such as:

- Streptococcus salivarius subsp. thermophilus
- Lactobacillus delbrueckii subsp. bulgaricus

can be used for more yoghurt-like products.

For specific products, combinations of mesophilic and thermophilic mixed cultures are also used to obtain specific, optimum product properties.

People with a lactose intolerance, which is particularly prevalent in the Southern hemisphere, cannot fully hydrolyze the lactose in milk. To reduce or hydrolyze the lactose in soft cheese, it is possible to cleave it with beta galactosidase (lactase) and thus to break it down into glucose and galactose.

The enzyme can be added to the process directly with the starter culture. After a coagulation time of 16 h at 22 to 25 °C, the majority of the lactose has been broken down into glucose and galactose. The reaction rate of the enzyme depends largely on the temperature and the pH value.

2.9 NPN content

NPN (non-protein nitrogen) refers to any non-protein nitrogens in the milk, such as urea. These constituents cannot be separated.

For this reason, it is especially important to know the exact NPN content during the different phases of the process, for example to allow interpretation of the residual protein content of the whey produced.

Fig. 1 shows the results of our own experiments, which have been confirmed by a qualitative assessment by the South German dairy industry experimentation and research institute in Weihenstephan.

As can be seen in fig. 1, the NPN content increases slightly from the raw milk to skim milk. The reason for this is that the NPN content of the skim milk is converted to a smaller, fat-free phase compared to the raw milk.

Similarly, the NPN content in the whey is higher after the separation process.

It must also be assumed that further NPN will be formed in addition to that in the milk.

Rennet and rennet alternatives added to the vat milk separate the caseinmacropeptide that acts as a protective colloid from the kappa casein. This and other proteolytic protein fragments released are also included in the NPN in the analyses.

If microbial acidification is used, the lactobacillae release proteinases, which preferentially break down kappa casein. Lactococci do not cause this process.

Essentially, it is true to say that rapidly acidifying cultures have a much greater proteolytic effect than slowly acidifying cultures.

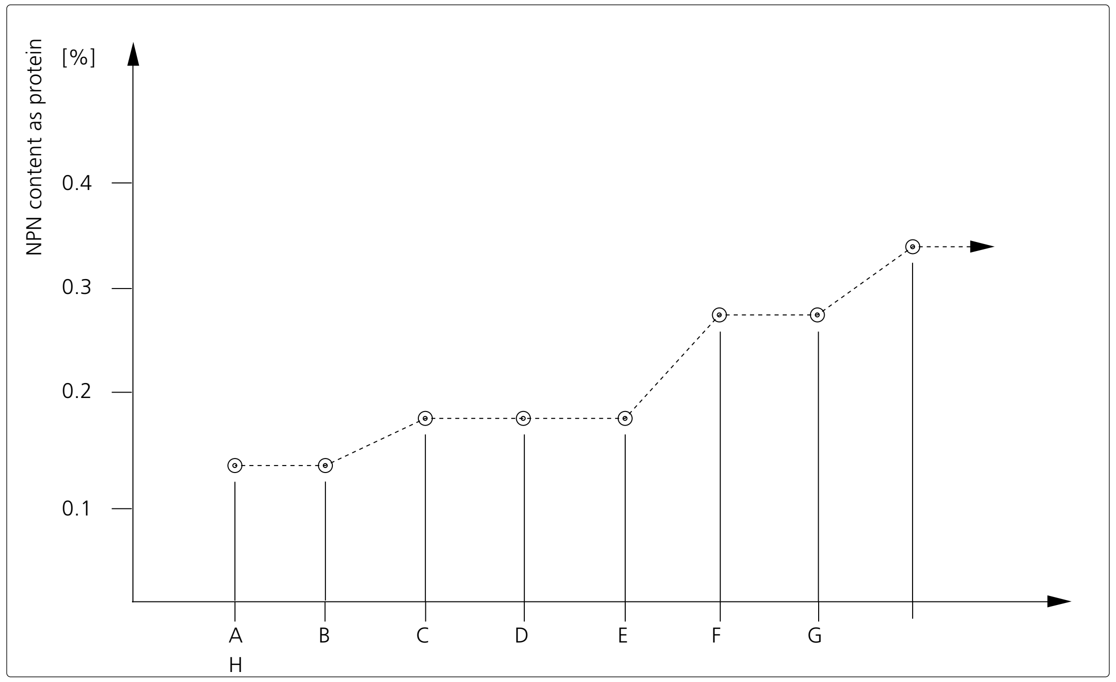


Fig. 1 Development of NPN content over the different process stages in the production of low-fat quark

A Raw milk in storage tank
B Raw milk before separator
C Skim milk after separator
D Skim milk (high heated)
E Coagulation tanks (feed)
F Coagulation tanks (discharge, pH approx. 4.6)
G Quark separator feed
H Whey discharge

2.10 Shelf life

Manufacturers specify different shelf lives for the various types of soft cheese. The important factor here is that the initial quality of the raw milk and the storage temperature of 4 – 6 °C are maintained. The raw milk must be at least pure and fresh, it may not contain any external flavors, it must be low in bacteria and free of retardants. The following data provides examples:

- Low-fat quark: At least 30 days*
- Half-fat quark: At least 30 days*
- Cream cheese: At least 90 days**
- Double cream cheese: At least 90 days**

* Can be extended by additional thermization
** Produced using the hot separation process

2.11 Other properties

The following additional properties can be specified:

Standard quark

- **Appearance / external:**
  Milky white to creamy yellow color
- **Appearance / internal and consistency:**
  Uniformly soft texture, smooth to buttery, added cream, including whipped, should be evenly distributed in the paste
- **Taste:**
  Light, fresh and lactic acidulated

Cream and double cream cheese

- **Appearance / external:**
  Milky white to light yellow color
- **Appearance / internal and consistency:**
  Buttery spreadable paste
- **Taste:**
  Light, fresh and slightly tangy

2.12 Analyses

Four examples from the soft cheese range are presented below. The specified figures are average values.

Low-fat quark

- 18.0 % DM
- 12.5 – 13.5 % protein
- 3.0 – 4.0 % lactose
- 0.5 – 1.0 % minerals
- Approx. 0.05% fat
- 82.0 % water
- pH 4.4 – 4.6
- Maximum 10.0 % FDM

Full-fat quark

- 40.0 % FDM
- Approx. 24.0 % DM
- 10.0 – 11.5 % protein
- 2.5 – 3.5 % lactose
- 9.6 % fat
- Approx. 76.0 % water
- pH 4.5 – 4.6
- 0.4 - 0.8 % minerals

Cream cheese

- 50.0 % FDM
- Approx. 36.0 % DM
- 14.0 % protein
- 3.2 % lactose
- 18.0 % fat
- 0.8 % minerals
- Approx. 64.0 % water
- pH 4.6 – 4.9

Double cream cheese

- 70.0 % FDM
- 44.0 % DM
- 30.0 – 30.5 % fat
- 2.5 % lactose
- 9.0 % protein
- 0.8 – 1.0 % minerals
- 46.0 – 48.0 % water
- pH 4.6 - 4.9

Abbreviations:
DM = Dry matter
FDM = Fat in dry matter
% = Percentage by weight

2.13 Calculations and formulae

The quark quantity and the specific skim milk consumption can be calculated using the following formulae:

$$M_{Mm} = \frac{DM_{Mm} - DM_{Mo}}{DM_{Mq} - DM_{Mo}}$$

Table for skim milk consumption per 1 kg quark depending on the dry matter in the quark (guideline values)

Dry matter	Specific skim milk consumption in kg per 1 kg quark	
	Standard process	Thermo process
17.0 %	4.04 kg	3.69 kg
17.5 %	4.22 kg	3.85 kg
18.0 %	4.41 kg	4.02 kg
18.5 %	4.59 kg	4.18 kg
19.0 %	4.78 kg	4.34 kg
19.5 %	4.96 kg	4.51 kg

Where DM_{Mm} = 8.8 %; DM_{Mo} = 6.1 % for standard process; DM_{Mo} = 5.75 % for thermo process

The table shows that the skim milk consumption per 1 kg quark always depends on the dry matter of the quark.
In addition, the specific skim milk consumption depends on the dry matter and its composition, in particular the proportion of available protein.

Based on: $m_{Mm} = \frac{DM_{Mq} - DM_{Mo}}{DM_{Mm} - DM_{Mo}}$

Or: $M_{Mq} = M_{Mm} \cdot \frac{e_{Mm} - e_{Mo}}{e_{Mq} - e_{Mo}}$

$m_{Mm} \cdot \frac{e_{Mq} - e_{Mo}}{e_{Mm} - e_{Mo}}$

Where:

M_{Mq} = Low-fat quark mass in kg
M_{Mm} = Skim milk mass in kg
m_{Mm} = Specific skim milk use in M_m / M_{Mq}
e_{Mm} = Protein content of skim milk in %
e_{Mq} = Protein content of low-fat quark in %
e_{Mo} = Protein content of whey in %
DM_{Mm} = Dry matter content of skim milk in %
DM_{Mq} = Dry matter content of low-fat quark in %
DM_{Mo} = Dry matter content of whey in %

For quark produced using the standard process, the e_{MO} values for whey are an average of around 0.8 percent, or 0.45 percent for thermo quark.

The 0.8 percent includes all of the protein that could not originally be used to produce cheese, i. e. the entire content of whey proteins and the NPN proportion. The NPN proportion is therefore around 0.35 percent in the whey.

These figures can vary with the protein content and the composition of the milk, which is a diverse raw material subject to natural and technological fluctuations (Fig. 1, p. 8). This also applies to the assumption of 0.45 percent as a residual protein content of the thermo quark whey.

The heat-induced aggregation of whey proteins on the cheese-producing casein thus sharply increases the yield from the thermo process by reducing the whey protein content.

The addition of cream to achieve the relevant fat level for full fat quark is calculated using this formula:

$$DM_{Qf} = \frac{DM_{Mq} \cdot f_{Ra}}{f_{Ra}\left[1 - 0.91 \cdot \frac{FDM}{100\,\%}\right] + DS_{Mq} \cdot \frac{FDM}{100\,\%} - 0.09 \cdot FDM}$$

DM_{Qf} = Dry matter of the quark to have its fat level adjusted in %
DM_{Mq} = Dry matter of the low-fat quark in %
f_{Ra} = Fat content of cream in %
f_{Qf} = Fat content of quark to be adjusted in %

FDM = Target fat content of the quark to have its fat level adjusted in %

When low-fat quark with 18 percent DM is mixed with cream with f_{RA} = 40 percent fat, the full-fat quark with 20 percent FDM has the following total dry matter:

$$DM_{Qf} = \frac{18 \cdot 40}{40\left[1 - 0.91 \cdot \frac{20}{100}\right] + 18 \cdot \frac{20}{100} - 0.09 \cdot 20}$$

DM_{Qf} = 20.86 %

Calculation of fat content of full-fat quark:

$$f_{Qf} = \frac{DM_Q \cdot FDM}{100\,\%} = \frac{20\,\% \cdot 20.86\,\%}{100\,\%}$$

f_{Qf} = 4.17 %

Calculation of cream quantity:

$$m_{Ra} = \frac{f_{Qf}}{f_{Ra} - f_{Qf}}$$

$$m_{Ra} = \frac{4.17\,\%}{40\,\% - 4.17\,\%}$$

m_{Ra} = 0.116 kg cream

To produce 1 kg of half fat quark with 20 percent FDM, 0.116 kg of cream with a fat content of 40 percent is required.

Abbreviations:

m_{Ra} = Specific cream quantity in kg cream / kg low-fat quark
DM_{Qf} = Dry matter of full fat quark as percentage of full-fat quark weight
f_{Qf} = Fat content of quark to be adjusted = FDM · $\frac{DM_{Qf}}{100\,\%}$

Yield calculation for double cream cheese

The adapted vat milk has e. g.
9.6 % Fat
7.8 % Fat-free dry matter
82.6 % Water

In other words, the total dry matter of the vat milk is 17.4 percent.

The whey obtained still has approx. 0.1 percent fat and a dry matter of approx. 6.0 percent DM. A cheese with 44 percent DM is produced. The quantity of cheese for the required quantity of milk is calculated as follows:

$$M_{FK} = M_{Fm} \cdot \frac{DM_{Fm} - DM_{Mo}}{DM_{FK} - DM_{Mo}}$$

$$M_{FK} = 100\text{ kg} \cdot \frac{(17.4\,\% - 6.0\,\%)}{(44\,\% - 6.0\,\%)}$$

M_{FK} = 30.0 kg

100 kg milk with 9.6 % fat thus gives:
30 kg cheese with x % fat (= $f_{abs.}$)
70 kg whey with 0.1 % fat

Thus:
$M_{Fm} \cdot f_{Fm} = M_{FK} \cdot f_{abs.} + M_{Mo} \cdot f_{Mo}$

Rearranging for the fat content of the cheese (= f_{abs}) gives:

$$f_{abs.} = \frac{M_{Fm} \cdot f_{Fm} - M_{Mo} \cdot f_{Mo}}{M_{FK}}$$

$$f_{abs.} = \frac{100\text{ kg} \,.\, 9.6\,\% - 70\text{ kg} \cdot 0.1\,\%}{30\text{ kg}}$$

$f_{abs.}$ = 31.76 %

The fat-free dry matter is then calculated as:
ffT = $DM_{FK} - f_{abs.}$
ffT = 44.00 % − 31.76 %
ffT = 12.24 %

The fat content in the dry matter is then:

$$FDM = \frac{100 \cdot 31.76}{44}$$

FDM = 72.18 %

100 kg milk with 9.6 percent fat thus provides 30 kg cheese with 44 percent DM and 72.18 percent FDM.

M_{Fk} = Soft cheese mass
M_{Fm} = Full-fat milk mass in kg
$f_{abs.}$ = Absolute fat content in cheese in %
f_{Fm} = Full-fat milk fat content
f_{Mo} = Whey fat content
ffT = Fat-free dry matter in %
DM_{FK} = Dry matter of full-fat cheese
DM_{Fm} = Dry matter of vat milk

3. Quark Production

3.1 Traditional process

Because of existing consumer habits, quark is still produced using the traditional process in Germany. It is also assumed that there will remain a market for this quark, which has a slightly coarser structure (also traded as layered white cheese), in the future.

3.2 Standard process

In this process, the skim milk is pasteurized using the high temperature short time (HTST) process (72 – 75 °C, holding time 15 – 30 sec). The pasteurized skim milk is cooled to between 28 °C and 30 °C and fed into the coagulation tanks. A special soft cheese culture should be used to acidify the skim milk.

The quantity of culture to be added depends on:

- Its acidification activity
- The temperature of the vat milk
- The holding time of the vat milk
- The end product taste to be obtained
- Selling or usage form

The quantity to be added is normally 0.5 to 1 percent starter culture.

After around 1.5 hours at a pH value of around 6.3, rennet is added to the vat milk. It is important to note that an excessive quantity of rennet has a negative effect on the taste of the end product. Normally 0.5 to 1 ml of liquid rennet per 100 l of vat milk is sufficient at a rennet strength of 1 : 10,000. After adding the rennet, the vat milk must be thoroughly stirred. During acidification after the addition of rennet, the stirrers must be shut down.

Once a pH value of 4.6 is reached, the gel is fractured and the curd / whey mixture is stirred thoroughly. This guarantees the homogeneity of the feed phase and therefore constant production conditions.

The vat milk is conveyed from the coagulation tank (1) to the feed tank (3) using a centrifugal pump (2). From the feed tank (3), the centrifugal pump (4) conveys the milk through a reversible double strainer (5), which retains coarse solid particles, to the quark separator (7). The feed regulator (6) ensures a constant feed to the separator. This is one of the preconditions for an even dry matter in the quark.

In the separator bowl, the acidified skim milk is separated into quark and whey. The whey is discharged under pressure without foam by the built-in centripetal pump. The quark flows out of the bowl through nozzles into the separator concentrate collector and subsequent quark hopper (8). A level sensor monitors the level in the quark hopper. A frequency controlled positive displacement pump conveys the quark from the quark hopper through the cooler (11) and then into the quark silo (15).

During the production of enriched quark, cream is continuously added to the low-fat quark with the positive pump (13). In the mixer (14), the quark and cream are evenly and gently mixed.

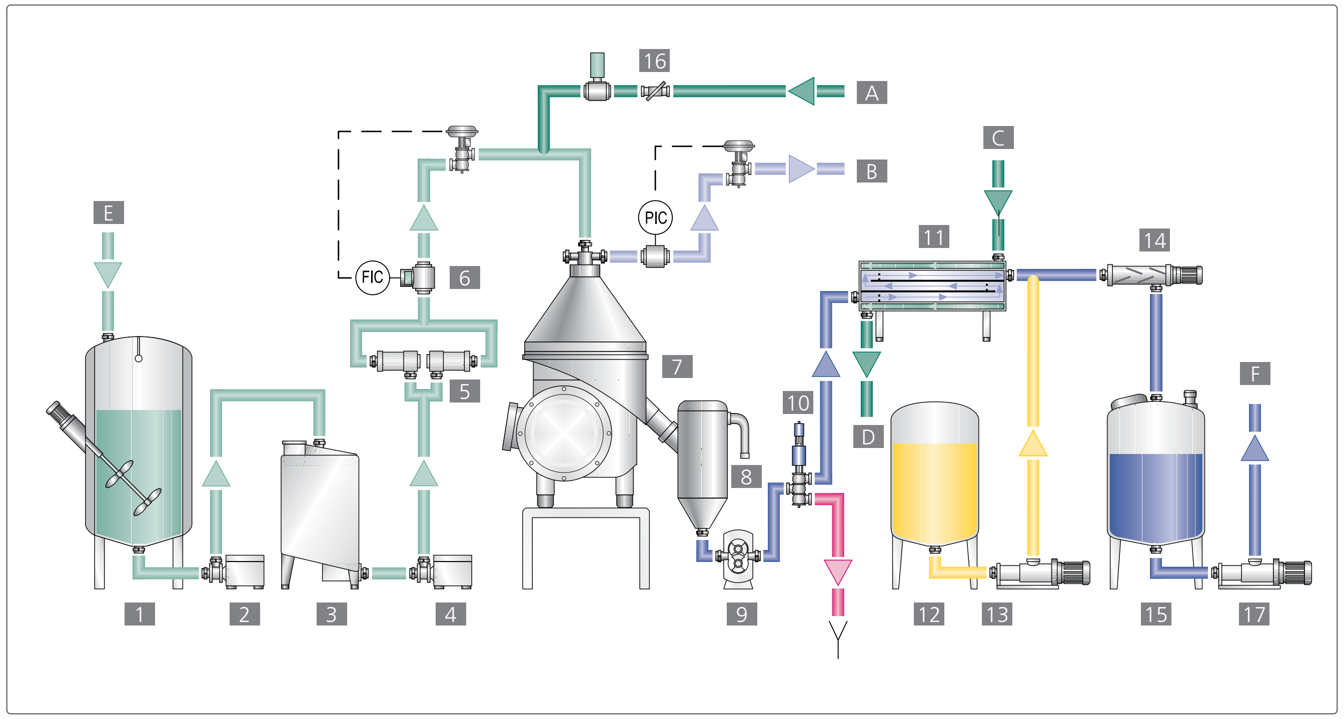


Fig. 2 Quark production using the standard process

1 Coagulation tank with stirrer
2 Self-priming centrifugal pump
3 Feed tank
4 Centrifugal pump
5 Double strainer (reversible)
6 Feed regulator
7 Quark separator
8 Quark hopper
9 Positive displacement pump
10 Reversing valve
11 Quark cooler
12 Storage tank for cream, fruit concentrate, herbs etc.
13 Cream pump
14 Quark mixer
15 Quark silo
16 Tubular strainer
17 Positive displacement pump
A Water feed
B Whey discharge
C Ice water feed
D Ice water discharge
E Skim milk feed
F To packaging

3.3 Thermo process

In contrast to the standard process, the thermo quark process involves different temperature / time treatment of the unacidified and acidified vat milk. This binds the majority of the whey protein from the skim milk to the casein and thus transfers it into the quark.

Description of process

The raw milk is skimmed in the separator (7) at 50 to 55 °C. The skim milk then reaches the plate heat exchanger (5), where it is heated to between 82 and 88 °C and kept hot in the regenerator (6) for 5 to 6 minutes.

The plate heat exchanger (5) is configured within a temperature difference $\Delta t \leq 2$ °C between the heating medium feed and the skim milk discharge temperature. The exact heating temperature is based on:

- Milk quality
- Time of year
- Separator configuration

The skim milk in the plate heat exchanger (5) is then cooled to the renneting temperature of 28 to 30 °C and conveyed to the coagulation tank (8).

Around 1.5 hours after culture has been added to the vat milk, rennet is added. The increased thermal load during the pre-treatment of the unacidified skim milk shifts the calcium-salt equilibrium. This causes the formation of calcium phosphate bridges, which result in firmer linking of the sub-micelles in the casein micelles. The formation of complexes between whey proteins and casein micelles sterically inhibits the coagulation enzymes used (rennet) by blocking the points of attack. Both of these make the vat milk sluggish to the rennet. This is offset by increasing the amount of rennet added in the thermo quark process by 20 – 50 percent compared to the standard process. This is still a very small quantity, i.e. approx. 1.0 to 1.5 ml liquid rennet per 100 liters of milk at a rennet strength of 1:10,000. Thorough stirring of the vat milk is then required. After around 16 hours, the desired pH value of 4.5 to 4.55 is reached.

To ensure that the feed to the separator is uniform and homogeneous, the cheese curd is stirred thoroughly in the tank (8). From the coagulation tank (8), the vat milk is conveyed to the balance tank (10) with a centrifugal pump (9). Installation of the balance tank (3) guarantees that the coagulum has a uniform composition, while the feed regulator (15) ensures a constant feed quantity to the separator.

The centrifugal pump (11) is used to convey the milk through the plate heat exchanger (12) and the regenerator (13) via the reversible double strainer (14) to the quark separator (16). The plate heat exchanger (12) must be configured in such a way that the temperature difference Δt between the heating medium feed (hot water) and the discharge temperature (vat milk) is less than 2 °C.

The thermization temperature for the coagulum (acidified and curdled skim milk) is 60 to 64 °C, and the holding time is between 4 and 6 minutes. The exact separation temperatures from 40 to 44 °C required are set by mixing part of the flow of the e. g. 60 degree coagulum with the coagulum cooled to approx. 35 °C. The coagulum is separated into whey and quark in the separator (16). The whey is discharged from the bowl without foam using the centripetal pump. The quark flows out of the bowl through nozzles into the concentrate collector and from there into the quark hopper (17). The adjustable positive displacement pump (18) conveys the quark through the cooler (20) and into the silo (24). To produce full-fat quark, for example, cream is continuously added to the quark using the metering pump (22). In the mixer (23), low-fat quark and cream are mixed to form a homogeneous product.

Compared to the standard process, the thermo quark process achieves an additional yield of around 10 percent due to the almost complete transfer of the whey protein into the quark.

The protein content of the quark whey after the standard process is 0.8 percent, while the residual protein content in the quark whey after the thermo process is just 0.45 percent. The vast majority of this is NPN (see Fig. 1, page 8), calculated at 0.35 percent.

$$M_{Mq} = M_{Mm} \cdot \frac{e_{Mm} - e_{Mo}}{e_{Mq} - e_{Mo}}$$

Where:

M_{Mq} = Low-fat quark mass in kg
M_{Mm} = Skim milk mass in kg
m_{Mm} = Specific skim milk consumption in kg skim milk / kg low-fat quark
e_{Mm} = Protein content of skim milk in %
e_{Mq} = Protein content of low-fat quark in %
e_{Mo} = Protein content of whey in %

Process	Quark quantity M_{Mq} from 100 kg skim milk	Milk consumption m_{Mm}
Standard	$100 \cdot \frac{3.4-0.8}{12.5-0.8} = 22.22$ kg	$\frac{100}{22.22} = 4.5$ kg Mm / kg low-fat quark
Thermo	$100 \cdot \frac{3.4-0.45}{12.5-0.45} = 24.48$ kg	$\frac{100}{24.48} = 4.08$ kg Mm / kg quark

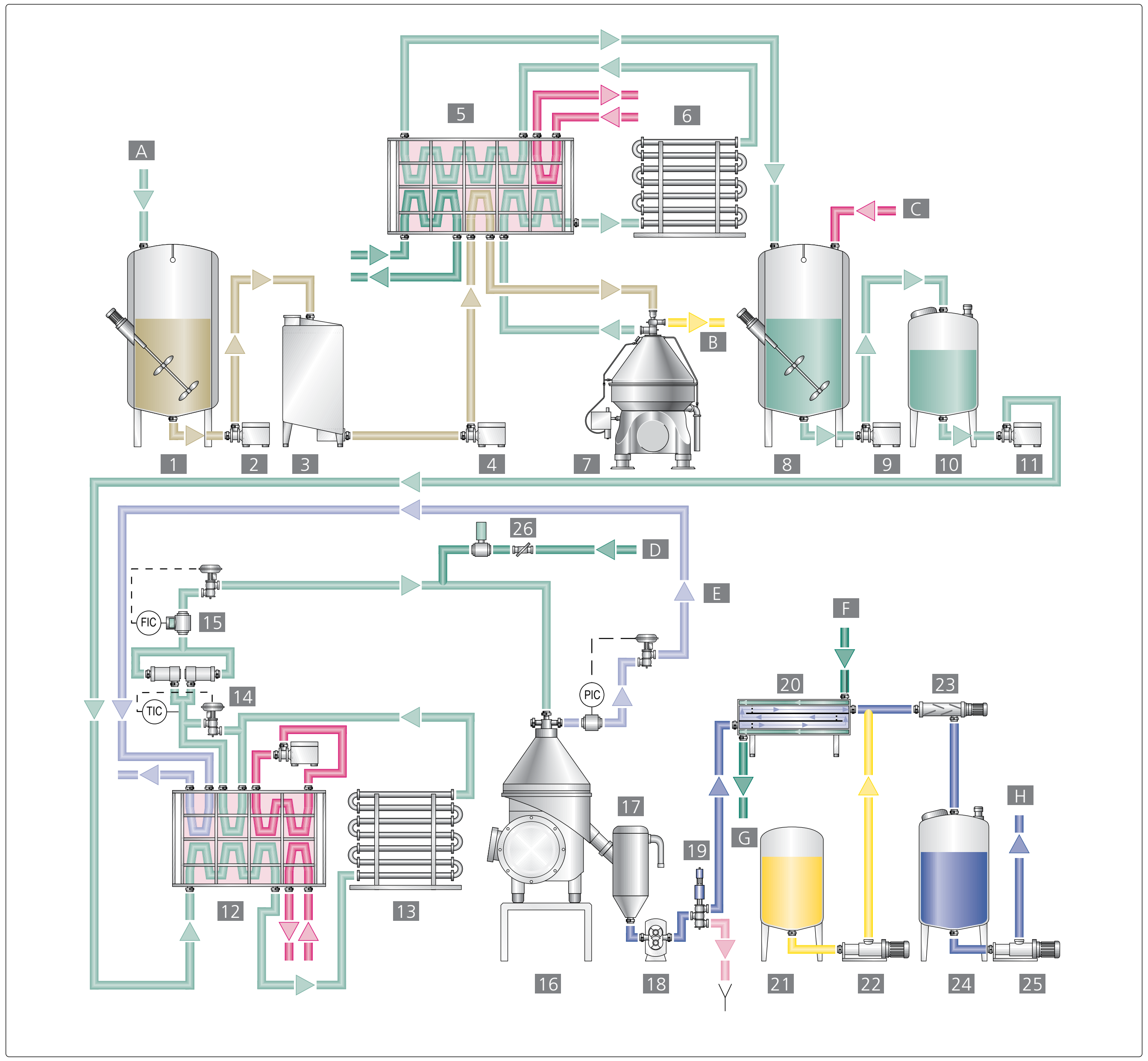


Fig. 3 Quark production using the thermo quark process

1 Raw milk silo with stirrer
2 Centrifugal pump
3 Balance tank
4 Centrifugal pump
5 Plate heat exchanger
6 Tubular regenerator
7 Skimming separator
8 Coagulation tank for vat milk with stirrer
9 Centrifugal pump
10 Balance tank with stirrer
11 Centrifugal pump
12 Plate heat exchanger
13 Tubular regenerator
14 Double strainer (reversible)
15 Feed regulator
16 Quark separator
17 Quark hopper
18 Positive displacement pump
19 Reversing valve
20 Quark cooler
21 Cream tank
22 Positive displacement pump
23 Quark mixer
24 Quark silo
25 Positive displacement pump
26 Tubular strainer

A Raw milk feed
B Cream discharge
C Culture and rennet dosing
D Water feed
E Whey discharge
F Ice water feed
G Ice water discharge
H To packaging

3.4 Soft cheese with high dry matter

This process involves a soft cheese that has a dry matter of at least 28 to 35 percent. This is the raw material for the production of sour milk quark, curd cheese and chocolate-covered protein bars (quark fingers), for example, with a wide variety of flavors. The raw material for this process is soft cheese with a dry matter content of approx. 14 to 18 percent. This material can be produced using either the standard or thermo quark process. The process is particularly well-suited as a supplement to a thermo quark process line.

After the buffer tank (1), a positive displacement pump (2) conveys the soft cheese to a tubular heat exchanger (3). The special tubular heat exchanger (3) is designed in such a way that the temperature difference between the hot medium feed and the discharge temperature of the soft cheese is less than 2 °C.

The feed temperature into the decanter (fig. 4)(5) is in the range of 60 – 65 °C. In the decanter, the concentration of solid content is increased to between 28 and 35 percent. Separation is carried out in the decanter (5) in a horizontal rotating bowl with an integrated coaxial scroll. This scroll also rotates, but with a variable differential speed. The residence time for the solids can be specified by adjusting the differential speed. The temperature setting and variation of the bowl speed and the differential speed between the bowl and the scroll can be used to set the optimum dry matter as required. A special displacement pump (6) conveys the concentrate to a scraped-surface heat exchanger (9).

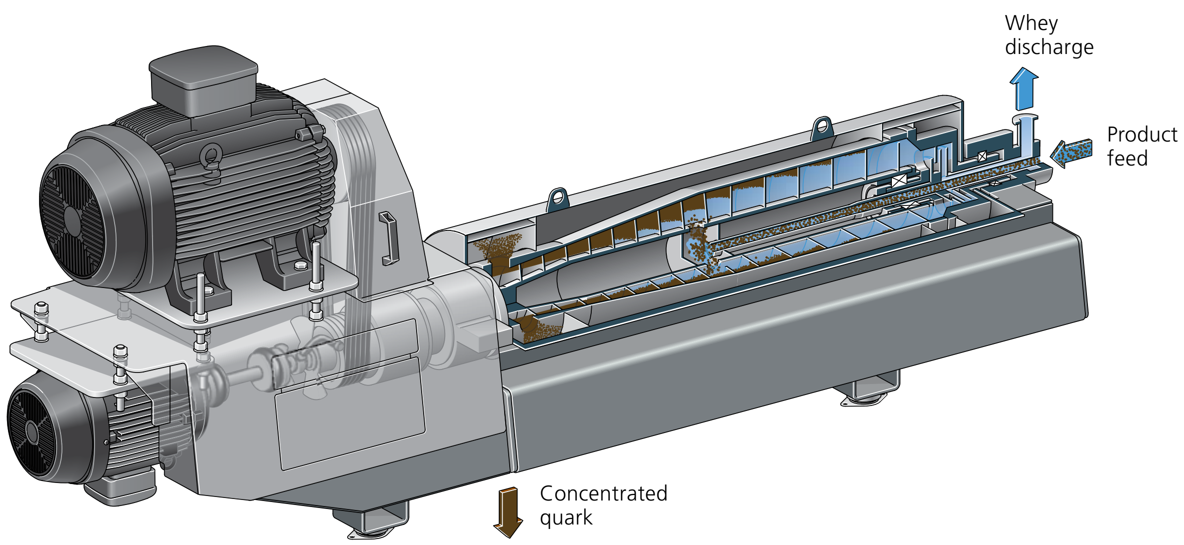
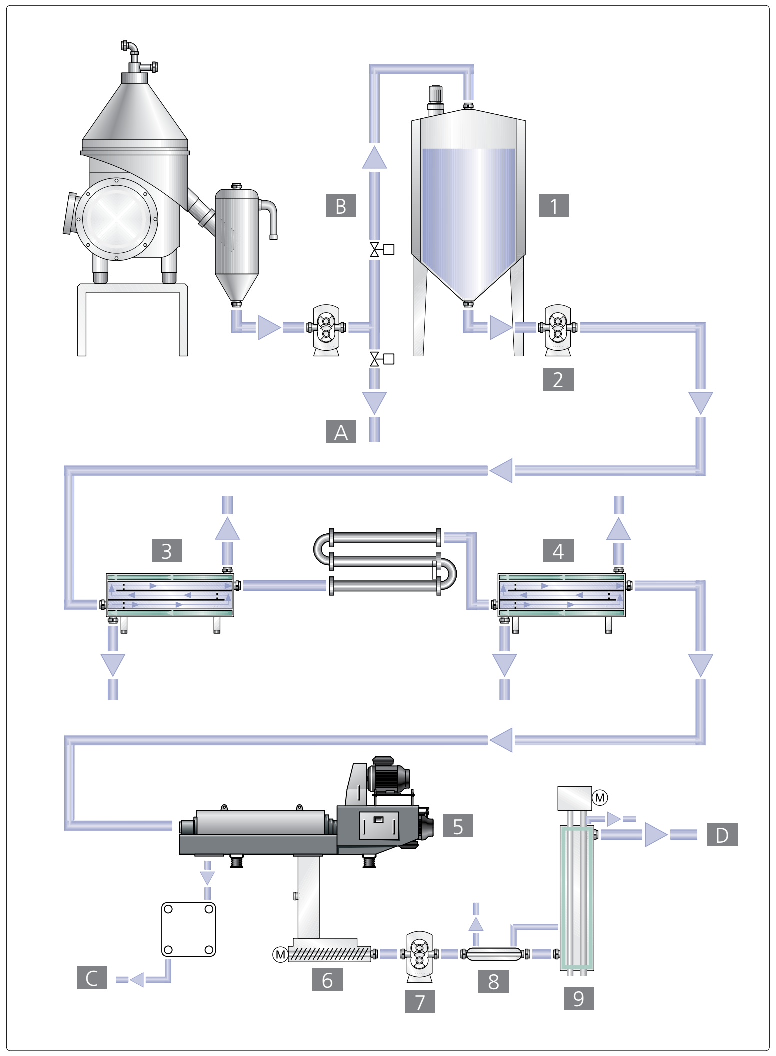


Fig. 4 Clarifying decanter **eco**force CF 4000



1 Buffer tank
2 Positive displacement pump
3 Tubular heat exchanger
4 Decanter
5 Special displacement pump
6 Positive displacement pump
7 Precooler
8 Scraped-surface heat exchanger

A Soft cheese
B Soft cheese to concentration
C Whey
D Concentrated quark

Fig. 5 Soft cheese with high dry matter

3.5 Use of membrane filtration

As well as using tried-and-tested separators to produce soft cheese products, in the last decades attempts have been made, with varying degrees of success, to optimize the production of quark products by using membrane systems. In membrane filtration, the pore size of the membrane determines the separation limit. The result is a concentrate (retentate) and a filtrate (permeate). A distinction is made between static and dynamic filtration, whereby the latter can be used in more applications. Spiral-wound and ceramic membranes are predominantly used, although hollow fibre and plate modules are also used.

Membranes can be used at various stages of the soft cheese production process. The use of membranes represents a supplementary and, in certain areas, alternative technology for the production of soft cheese products.

3.5.1 Preliminary concentration of vat milk

When producing standard quark, it is possible to use filtration to concentrate the vat milk before the acidification stage, i. e. the concentration of protein important for the process is raised, minor constituents are removed. To do this, the raw or previously thermatized skim milk is heated to a filtration temperature of around 50 °C and fed to a filtration system. The membranes are selected in such a way that the caseins remain in the retentate and their concentration is raised. Starting from a dry matter of around 9 percent, the concentration of the skim milk can be increased to around 12 percent, and around 5 percent protein. The resulting permeate only contains whey proteins, lactose and ash. This permeate is referred to as ideal whey, has various uses and is extremely interesting from a nutritional perspective. The acid whey produced is significantly reduced by this upstream process step and, as previously described, a sweet milk permeate is obtained instead. This retentate from filtration can be used to produce a classic thermo quark with the separator, for example, although the process must take account of the increased dry matter, which means that slight modifications to the process are necessary.

3.5.2 Sour whey treatment (by-product processing)

Further possible applications of membranes include the filtration of the acid whey after the quark separator. The following two process variants are used for processing sour whey.

3.5.2.1 Concentrate dosage

These whey proteins are concentrated in the retentate to a dry matter of around 17 – 19 percent, leaving behind the permeate, which is almost free of whey proteins. The concentrate / retentate is subjected to high temperature heating to bring about milk protein precipitation and is then homogenized. After these steps, it is mixed with the quark extracted from the separator. This process gives the standard process the advantage of incorporating the whey proteins and thus increasing yield. However, the amount of retentate that can be added is limited due to sensory disadvantages and, according to current thinking, is specified at 80 percent.

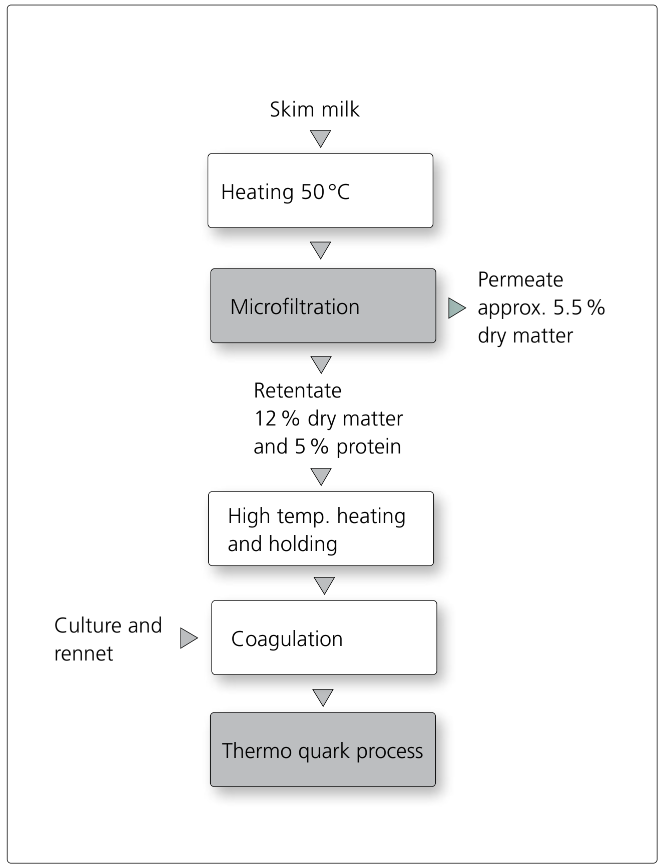


Fig. 6 Schematic diagram of preliminary concentration of vat milk

3.5.2.2 Whey protein concentrate recovery

A whey protein concentrate (WPC 60) is produced from the sour whey by means of ultrafiltration (UF). The permeate from this filtration can subsequently be further processed by means of reverse osmosis (RO) filtration. In this way, a retentate is recovered with a high lactose content and a permeate is obtained consisting of water which can be recycled back into the production process as flush water.

3.5.2.3 Microparticulation

The WPC 60 from the process described above is subjected to microparticulation with the aid of a combined thermal and mechanical treatment. In this process, the whey protein concentrate develops a special, very high-grade structure, similar to a cream. This product can be used, for example, as a fat substitute or also as a natural stabilizing agent.

Fig. 7 Installation for the microparticulation of WPC 60

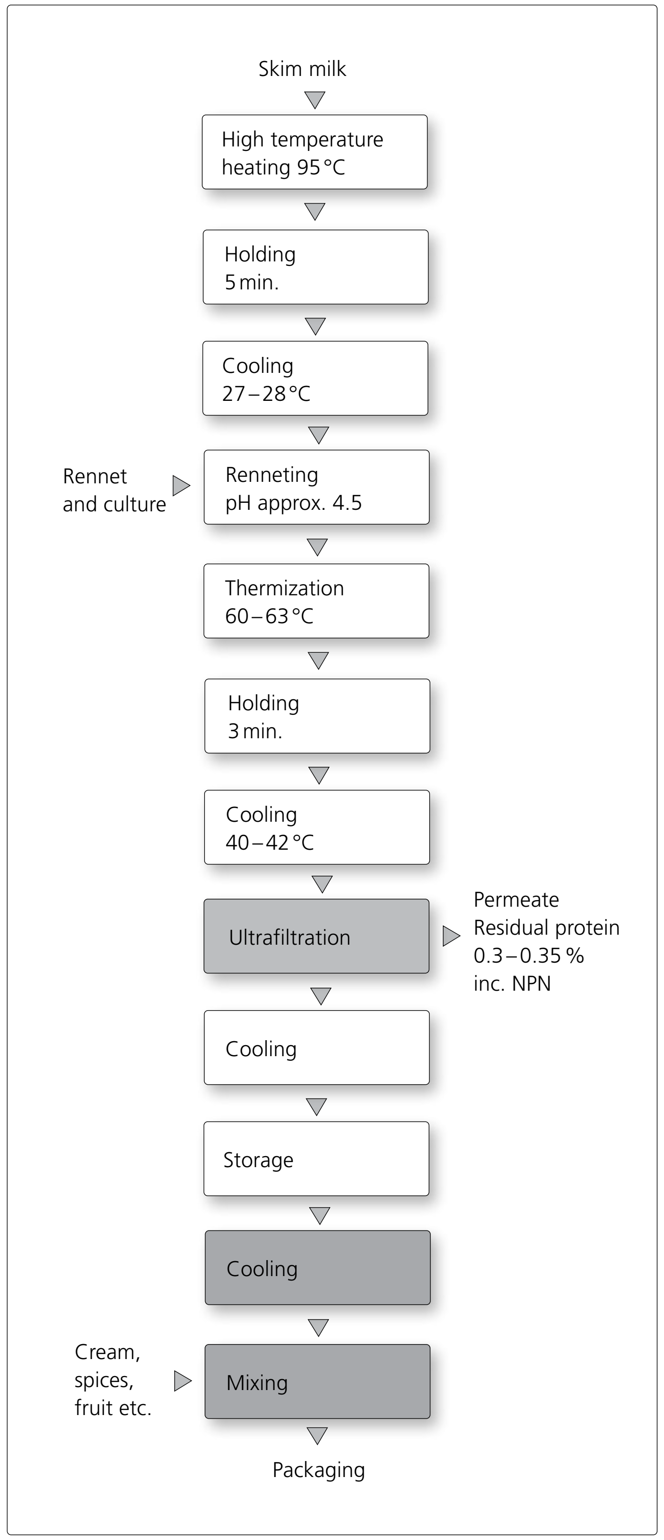


Fig. 8 Schematic diagram of quark production using ultrafiltration systems

3.5.4 Summary

The use and combination of filtration and separation technology offers a wide range of possibilities. When one considers the pure quark production, in terms of the product structure the separator for separation of the coagulate still plays the dominant role. As well as this consideration, an assessment of the economic efficiency of the different process should be carried out for specific individual projects. The slightly better quantities obtained with the membrane process need to be set against the higher investment and operating costs. A further issue is the acceptance of the product characteristics, in particular whether the products can stand up to a quality comparison.

Filtration technology as a supplement to mechanical separation technology enables, for example, a reduction of the sour whey content through preconcentration of the vat milk or the recovery of valuable by-products from the whey by downstream membrane processes.

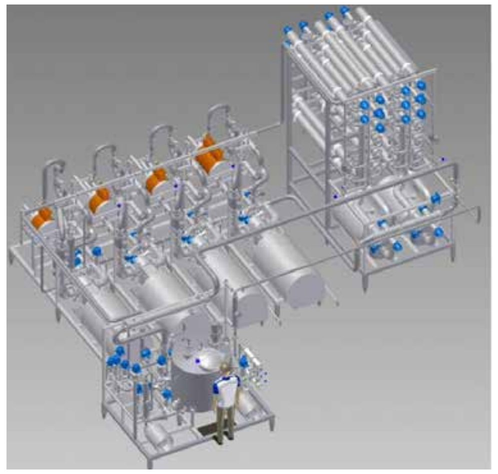


Fig. 9 Membrane system with spiral wound and plate modules

3.5.3 Full concentration using micro/ultrafiltration

Depending on the process, this process uses either micro or ultrafiltration as well as combinations of different membrane types such as spiral wound and plate modules. The preparatory process steps for pretreatment and curdling are comparable with those for classic thermo quark. The membrane system is then used to raise the concentration of the treated coagulate and separate it from the acid whey. The acid whey released by the process has a dry matter of around 5.5 percent. The dry matter of the quark can be up to around 40 percent, depending on the fat content, but this is only useful for producing special products because of economic considerations. The composition and structure of the end product differs depending on the filtration process – particularly when compared to classic separator quark.

	Thermo quark (KDB)	MF filtration (ceramic membrane)	UF filtration (spiral-wound modules)
Effectiveness/yield	++	++	+++
Investment costs	+++	++	+++
Operating costs	+++	++	++
Service costs	++	++	++
Service life	+++	+++	+
Product quality	+++	+++	++
Total	16	14	13

Fig. 10 Comparison of filtration and thermo quark process

3.6 Quark from Buttermilk

3.6.1 From cultured buttermilk

Essentially, the production of buttermilk quark is very similar to the production of a standard quark. However, in this case, using the highest possible quality of buttermilk is vital, as otherwise oxidation processes can result in negative effects in terms of taste (page 22, fig. 11).

The buttermilk coming from the buttermaking machine is stored in the silo (1), To achieve a bacteriologically perfect product, it is thermized (temperature 65–70 °C, holding time 40 sec) and then cooled to between 42 and 45 °C. The buttermilk must remain in the tank at this temperature for around 60 minutes. After this residual time, the pump (5) conveys the milk to the feed tank (7). Here, the buttermilk is degassed by the built-in stirrer. The centrifugal pump (8) then conveys the milk through the strainer (9) to the quark separator (12). The feed regulator (10) guarantees a constant feed rate to the quark separator. The separator separates the buttermilk into protein and serum. The protein (buttermilk quark) is drained through the nozzles fitted in the bowl shell.

The serum is discharged by the centripetal pump without foam and under pressure. The fat from the buttermilk – 0.2 to 0.5 percent – is retained half and half by the quark and the serum. The buttermilk quark is conveyed from the quark hopper (13) through the tubular cooler (16) to the mixer (19) using the pump (14). The pump (18) is used to add cream or other ingredients such as fruit concentrate to the quark. Buttermilk quark is ideal for quark preparations as it contains lecithin, which is a good emulsifier.

3.6.2 From sweet buttermilk

The buttermilk is collected in the tank (1) and is conveyed through the plate heat exchanger (3) to the coagulation tank (4) by the pump (2). Thermization is performed at a temperature of around 72 °C and with a holding time of 40 seconds. The buttermilk is then cooled to a renneting temperature of between 28 and 30 °C. With sweet buttermilk, curdling is now carried out using culture and rennet, as for obtaining quark from skim milk. After around 16 hours, a pH value of around 4.5 is reached. The acidified buttermilk is agitated and conveyed through the plate heat exchanger (6) to the reaction tank (7) using the pump (5). Thermization is carried out at 58 to 60 °C. The optimum separating temperature is between 42 and 45 °C. The subsequent production process is the same as that described in section 3.6.1.

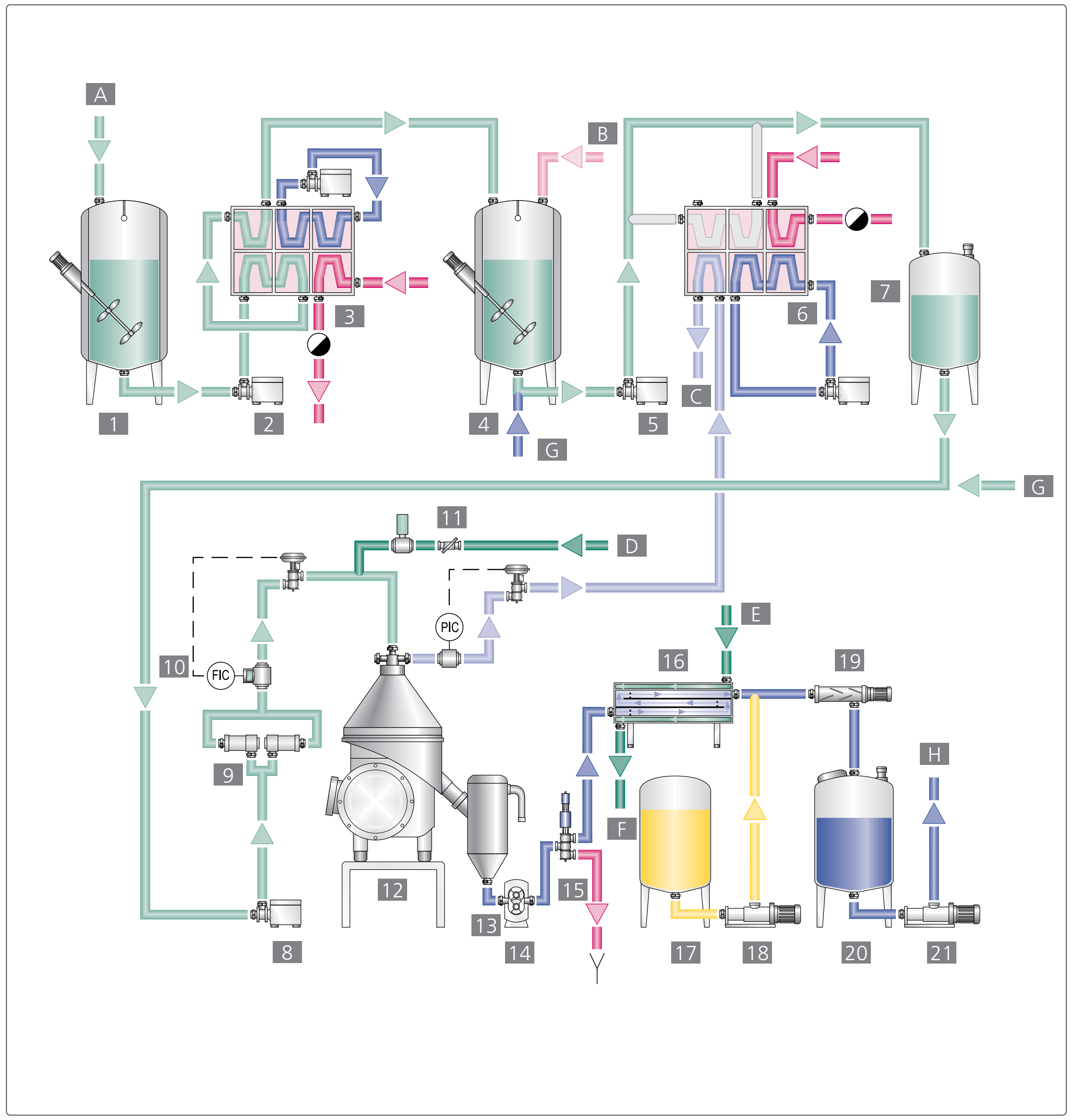


Fig. 11 Quark production from buttermilk

1 Buttermilk tank
2 Centrifugal pump
3 Plate heat exchanger
4 Coagulation tank
5 Centrifugal pump
6 Plate heat exchanger
7 Feed tank with stirrer
8 Centrifugal pump
9 Tubular strainer (reversible)
10 Feed regulator
11 Tubular strainer
12 Quark separator, type KDB
13 Quark hopper
14 Positive displacement pump
15 Reversing valve
16 Quark cooler
17 Tank for fruits, cream etc.
18 Positive displacement pump
19 Quark mixer
20 Silo
21 Positive displacement pump

A Buttermilk feed
B Culture and rennet feed (sweet buttermilk only)
C Whey discharge
D Water feed
E Ice water feed
F Ice water discharge
G Displacement water
H To packaging

3.7 Quark from Recombined Milk

For some years, quark or products similar to quark have been produced from recombined milk in some countries, as insufficient fresh milk is available.

3.7.1 From skim milk powder

Recombined skim milk is a milk that is primarily produced by mixing skim milk powder with water. There are three kinds of milk powder, which are rated using the WPNI index (whey protein nitrogen index). This index specifies the proportion of **non**-denaturated whey proteins in the powder.

WPNI index

- Low heat powder: 4.5 – 6.0 mg / g
- Medium heat powder: 1.5 – 4.5 mg / g
- High heat powder: ≤ 1.5 mg / g

"Low heat powder" should be used if the quark is being produced using the standard process. When using "medium heat powder", quark production should be performed using the thermo process. "High heat powder" is unsuitable.

3.7.2 Process

Skim milk powder is dissolved in warm water at a temperature of 36 to 38 °C at a ratio of 1 : 10. The dissolved powder should be left to swell for at least 60 minutes with the stirrer running slowly. After swelling, the recombined milk must be pasteurized. The milk should be separated before pasteurization to centrifuge off dissolved protein particles. Otherwise, a large filter has to be used. To overcome the rennet inertia, around 5 – 6 g of $CaCl_2$ per 100 l of vat milk should be added to the milk. Acidification and separation for recombined milk are the same as for fresh milk.

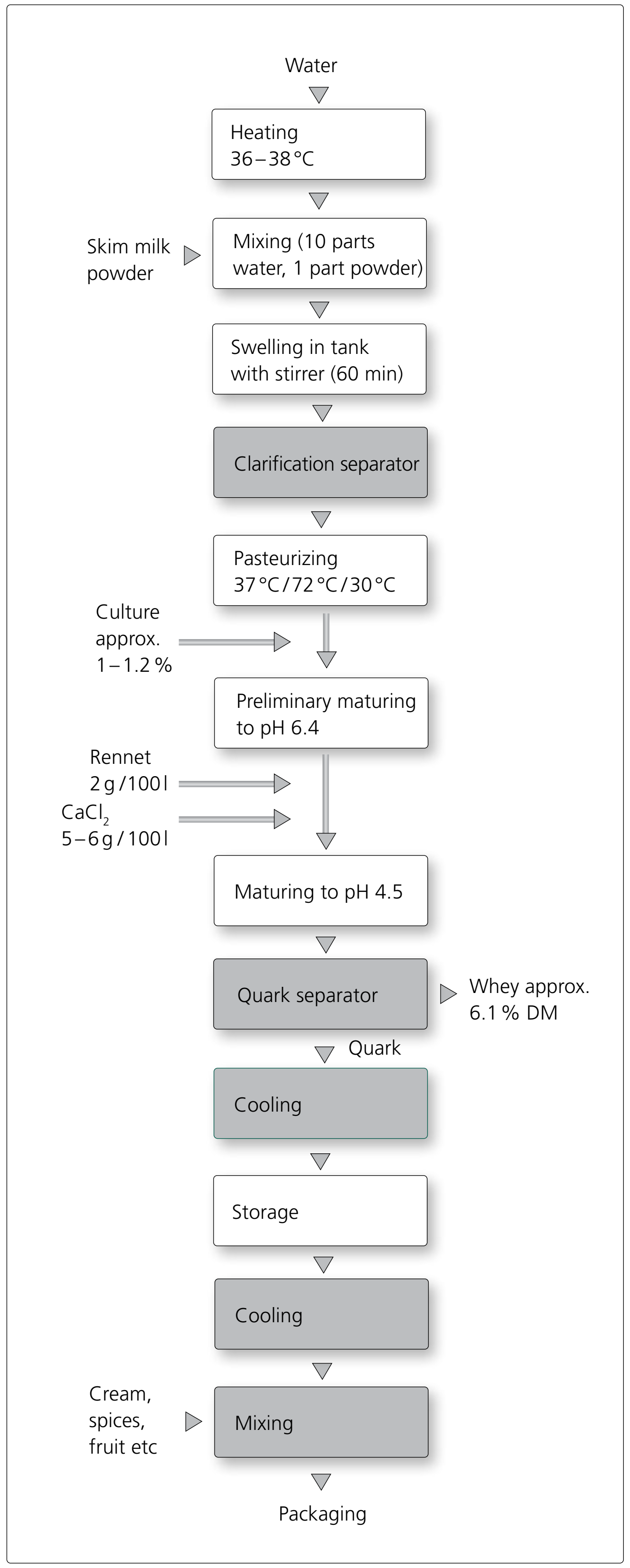


Fig. 12 Schematic process for quark production from skim milk powder

3.7.3 From whole milk powder

In some countries, only whole milk powder is available. In such cases, the recombined milk is skimmed before acidification. The skim milk still has a residual fat content of between 0.8 and 1 percent. This fat adheres strongly to the protein and 90 percent of it is discharged with the quark during separation. This means that the absolute fat content of the quark is around 3 to 4 percent. For quark with 20 percent DM, this corresponds to an FDM value of 15 to 20 percent.

4. Labaneh Production ("Strained Yoghurt")

The skim milk is heated to between 42 and 44 °C and fed into the vat milk tank. Yoghurt culture is used to acidify the milk. After an acidification time of 3 to 4 hours, a pH value of around 4.4 to 4.5 is attained. The acidic milk is agitated and conveyed to the separator.

The size of the vat milk tank should correspond to a maximum of the hourly capacity of the separator, as otherwise acidification advances too far. As the milk is acidified using yoghurt culture rather than rennet, separation of protein and whey in the separator is more difficult. For this reason, the separator capacity drops by around 30 percent compared to the standard process, depending on the desired dry mass value. The yoghurt quark (Labaneh) coming from the separator is cooled and mixed with cream or other fats. The normal dry matter is 15 – 24 percent.

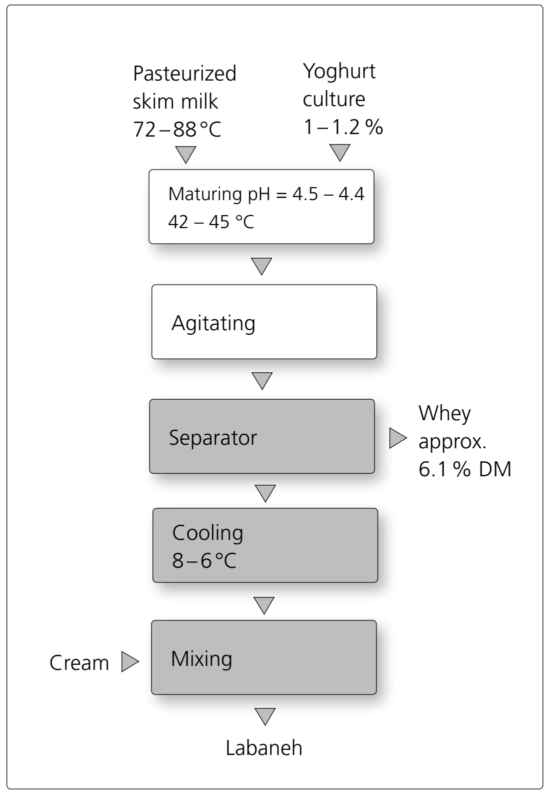


Fig. 13 Schematic overview of Labaneh production

5. Labneh Production

Labneh is produced from a standardized milk with approx. 3 percent fat. The product has around 24 percent DM with an FDM content of 40 percent. The standardized milk is heated to 50 – 55 °C, homogenized at this temperature and, after cooling to around 43 °C, conveyed to the coagulation tank for acidification. Yoghurt culture, around 1 to 1.5 percent, is used to acidify the milk. After around 4 hours, the vat milk has a pH value of between 4.6 and 4.8. The acidified milk, also known as Laban, is agitated and heated to a separating temperature of 60 °C in the plate heat exchanger. To ensure proper separation, the coagulated milk is degassed for around 15 minutes in an intermediate tank. A centrifugal pump conveys the milk through a reversible double filter to the separator. The Labneh coming from the separator is mixed with spices in a tank. The cheese is then packed.

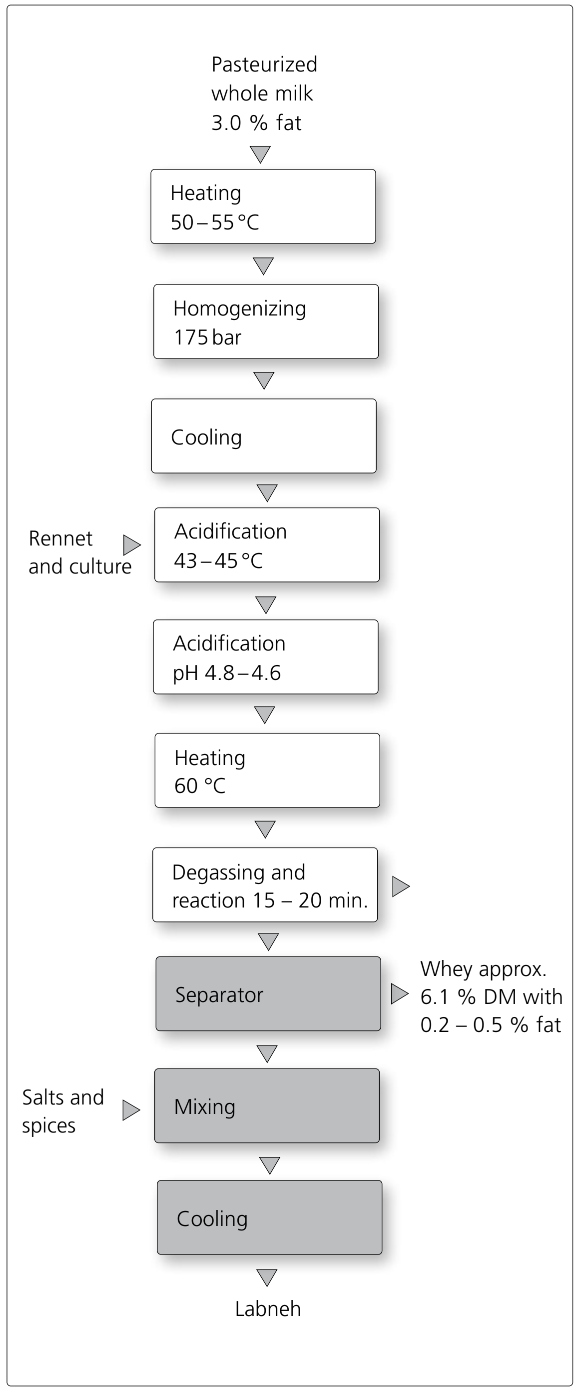


Fig. 14 Schematic overview of Labneh production

6. Cream Cheese Production

6.1 Technology

Cream cheese is a soft cheese with a fat content of 40 to 50 percent fat in dry matter. The total dry matter is at least 36 to 39 percent. In terms of structure and taste, it is similar to double cream cheese. The initial product is pasteurized, standardized milk with max. 3.5 percent fat. Homogenization is used to accumulate the fat on the protein. The specific gravity of the cheese mass is greater than that of the whey. During separation in the separator, the cheese mass is centrifuged outwards. The whey separated off in the separator contains 0.2 to 0.5 percent fat. This fat content can be reduced to around 0.1 percent through subsequent skimming with a specially designed skimming separator.

The cheese separated off in the separator has a max. dry matter of 28 percent with an FDM content of around 44 percent. Subsequent addition of cream raises the dry matter and the FDM content to the required level. Salt and spices are added according to the producer's recipes.

The finished cheese can be packaged when hot and then cooled in a cooling tunnel.

6.2 Process

The standardized and pasteurized milk is conveyed from the storage tank (1) through the plate heat exchanger (3) to the homogenizer (4) using the centrifugal pump (2). The milk heated to 55 °C in the plate heat exchanger is homogenized at around 175 bar. The milk is then cooled to a coagulation temperature of between 25 and 27 °C and conveyed to the coagulation tank (5). Adding 1 to 1.5 percent starter culture causes acidification of the milk. To obtain a firm gel, around 0.5 ml rennet per 100 l milk (liquid rennet with rennet strength 1 : 10,000) is added after around two hours. After a coagulation time of 15 to 16 hours, the pH value is 4.7 – 4.8. The gel is then agitated and conveyed through the plate heat exchanger (7) to the reaction tank (8) by the centrifugal pump (6). The coagulated milk is heated to around 60 °C in the plate heat exchanger.

The temperature difference Δt between the hot medium feed and the coagulated milk at the discharge may not be greater than 2 °C.

Both reaction tanks are fitted with a slow-running stirrer. The dwell time in a continuous process is 15 minutes in each case. The pump (9) conveys the preheated milk to the plate heat exchanger (10). Here, it is heated to 80 °C and then reaches the second reaction tank (11). This has the same functions as the first reaction tank.

The pump (12) conveys the milk heated to 80 °C to the separator (15). The feed regulator (14) guarantees a constant feed rate. The cheese is continuously discharged from the separator bowl through nozzles.

The whey is discharged without foam and under pressure by a centripetal pump. From the separator, the hot cheese flows into the collecting tank (16). A positive displacement pump (17) conveys the cheese to the mixing tanks (20). There, cream or other ingredients are added, with mixing taking place discontinuously in batches. The pump (21) conveys the finished cheese for cooling (22) or packaging (F).

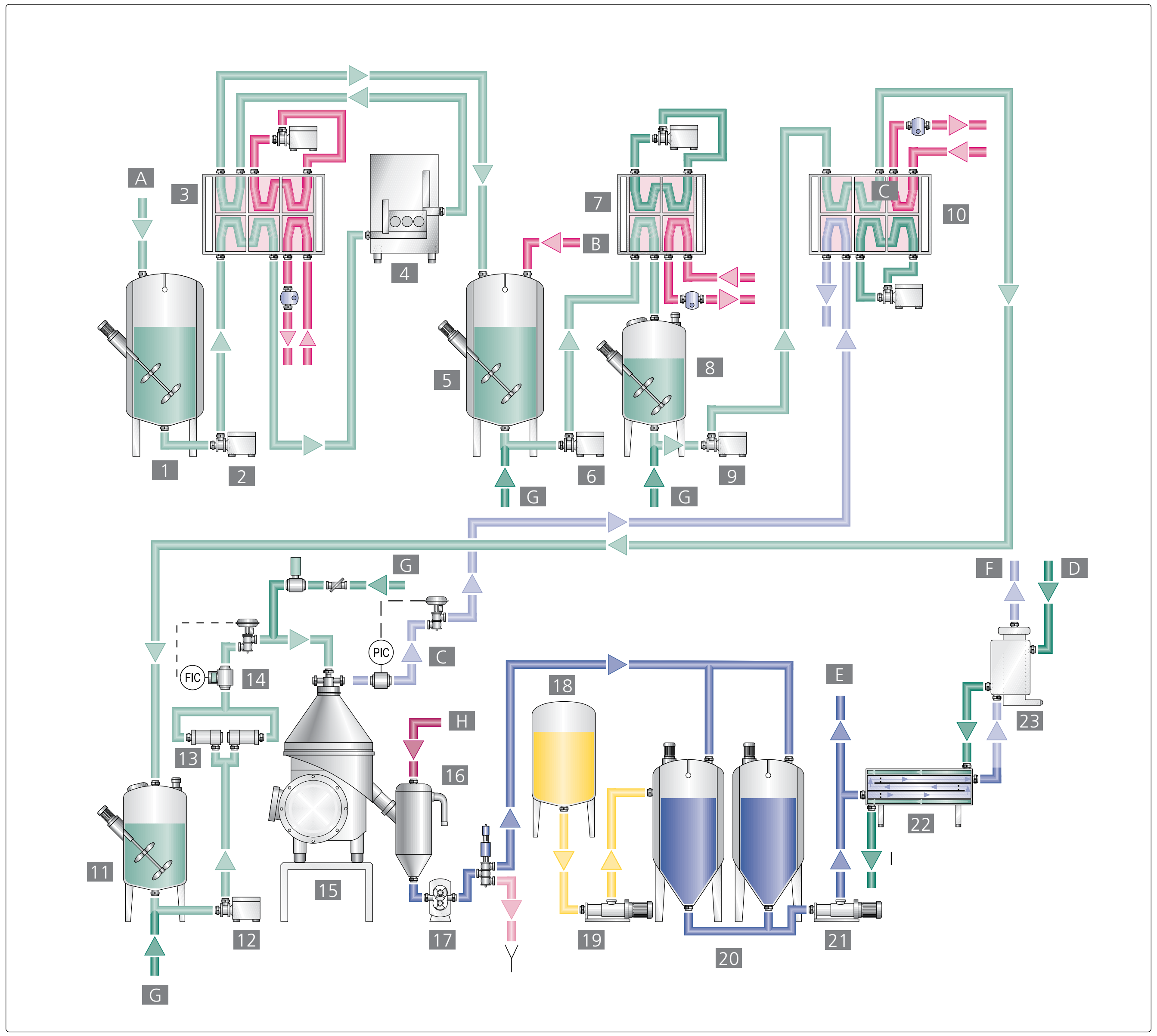


Fig. 15 Cream cheese production

- 1 Storage tank
- 2 Centrifugal pump
- 3 Plate heat exchanger
- 4 Homogenizer
- 5 Coagulation tank
- 6 Centrifugal pump
- 7 Plate heat exchanger
- 8 Reaction tank
- 9 Centrifugal pump
- 10 Plate heat exchanger
- 11 Reaction tank
- 12 Centrifugal pump
- 13 Double strainer (reversible)
- 14 Feed regulator
- 15 Quark separator
- 16 Collecting tank
- 17 Positive displacement pump
- 18 Cream tank
- 19 Positive displacement pump
- 20 Mixing tank
- 21 Positive displacement pump
- 22 Precooler
- 23 Scraped-surface heat exchanger
- A Pasteurized milk 1.5 – 3.5 % fat
- B Culture and rennet feed
- C Whey discharge
- D Cooling-medium feed
- E Soft cheese for hot packaging 65 – 70 °C
- F Soft cheese for packaging 10 – 12 °C
- G Water supply
- H Salt addition
- I Cooling medium return

7. Double Cream Cheese Production

Double cream cheese is a light, paste-like, spreadable cheese with a slightly tangy taste. It is a soft cheese with a fat content of at least 60 percent FDM and a total dry matter of 44 to 46 percent.

7.1 Technology

The initial product for double cream cheese is normally a standardized, pasteurized milk with a fat content of 8 to 14 percent. The enriched milk is homogenized at a temperature of around 55 °C. This combines the milk fat with the protein. The fat / protein mixture thus has a lower specific gravity than the whey. The specific gravity of the whey is around 1.0245 kg / dm^3 and the fat / protein mixture around 0.93 kg / dm^3. If the fat proportion shifts to below 7 percent, the specific gravity of the fat / protein mixture approaches that of the whey. Proper separation is no longer possible. However, a shift in the fat content to between 12 and 15 percent does not present any processing problems.

7.2 Process

The standardized and pasteurized milk from the storage tank (1) is conveyed through the plate heat exchanger (3) to the homogenizer (4) by a centrifugal pump (2). The milk is heated to 50 to 55 °C and homogenized at 175 / 40 bar (in 2 stages). After cooling to around 22 – 25 °C, it reaches the coagulation tank (5). Curdling is carried out at this temperature with 1 to 1.5 percent starter culture or DVS culture. To obtain a firm gel, 0.5 ml rennet per 100 l milk (liquid rennet with rennet strength 1 : 10,000) is added around 2 hours after adding the culture.

After a holding time of 12 to 16 hours, the pH value is 4.9. The gel is then agitated and conveyed via the plate heat exchanger (7) to the reaction tank (8) using the centrifugal pump (6). The fermented milk is heated to 77 – 82 °C. The tank is fitted with a slow-running stirrer. The reaction time for a continuous process is 15 to 20 minutes. The pump (9) conveys the hot, fermented milk to the separator (10). With a dry matter of around 44 percent, approx. 40 percent of the feed quantity is separated out as cheese and is conveyed into the collecting tank (11) without pressure by a centripetal pump. The dry matter in the cheese can be adjusted by regulating the whey discharge pressure.

The cheese is conveyed into the mixing tank (15) using the positive pump (12). In the mixing tank, herbs, spices or cream are added to the cheese. Salt is added earlier in the collecting tank (11) using a salt metering unit. To obtain a good texture and mixture, the cheese is mixed for 30 minutes in the tank (15) at around 75 °C.

The finished double cream cheese is packaged when hot and then cooled in a cooling tunnel. Two-stage cooling is an optional alternative.

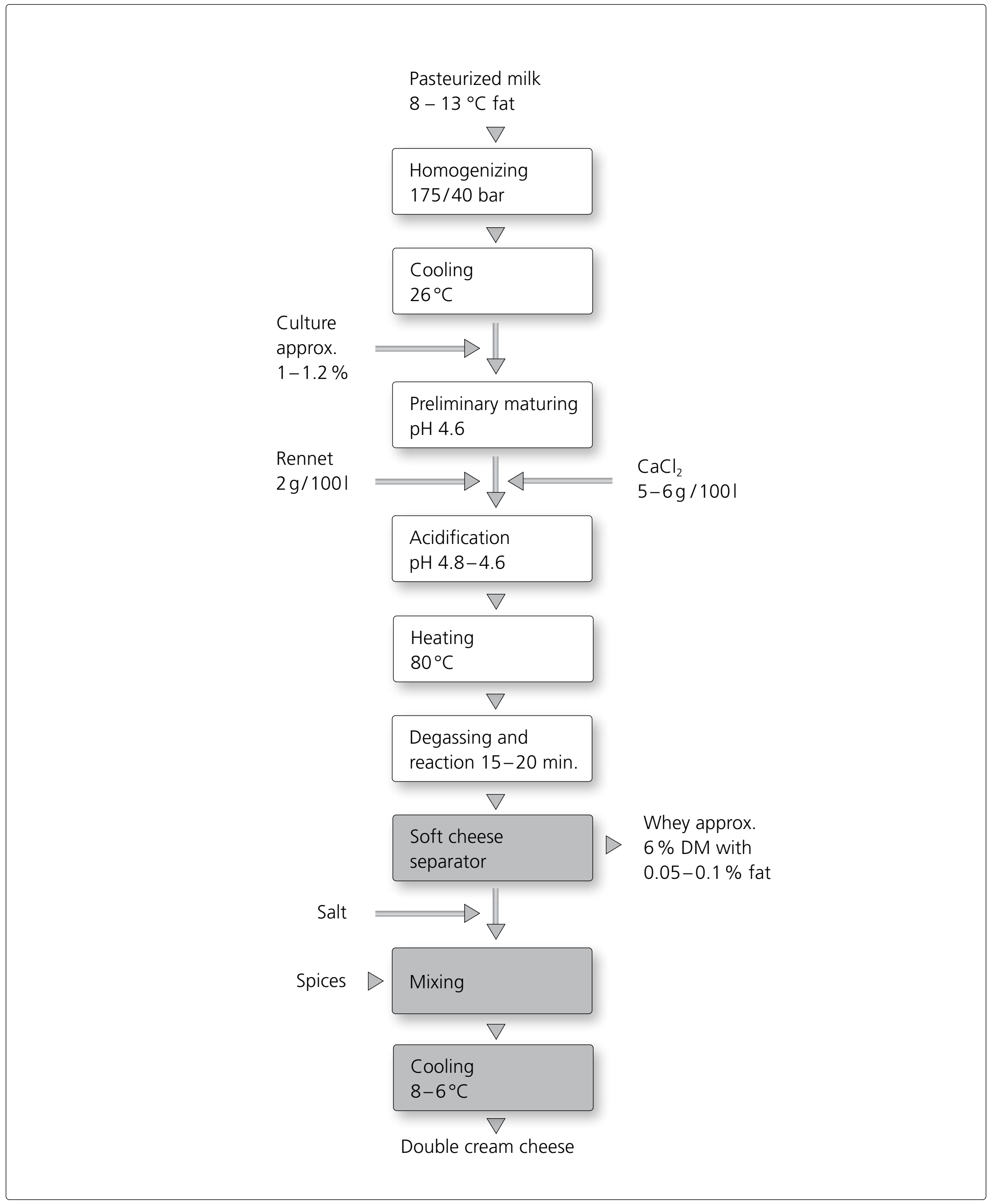


Fig. 16 Schematic overview of double cream cheese production

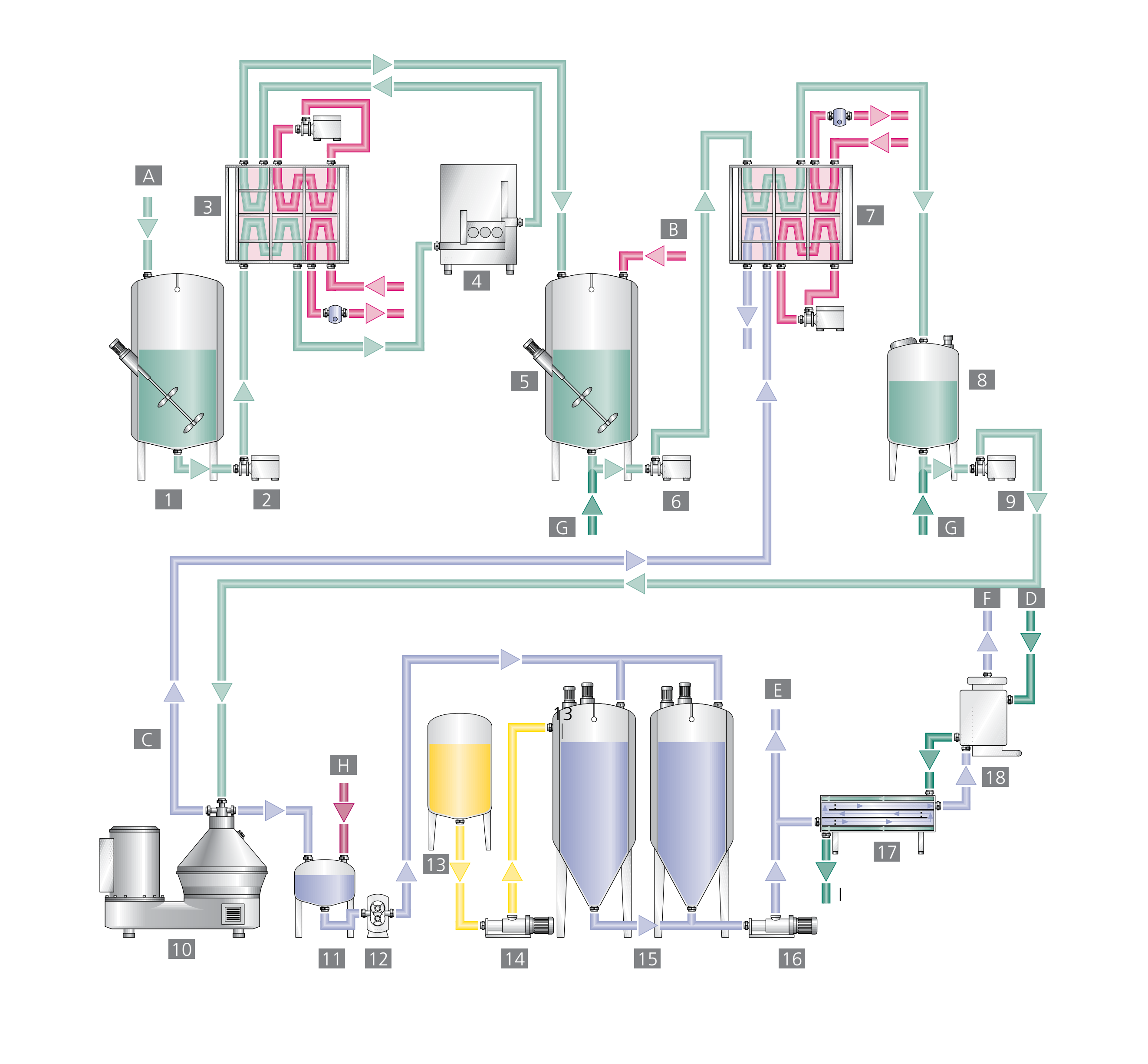


Fig. 17 Double cream cheese production from standardized, pasteurized milk

1 Milk storage tank with stirrer
2 Centrifugal pump
3 Plate heat exchanger
4 Homogenizer
5 Coagulation tank
6 Centrifugal pump
7 Plate heat exchanger
8 Reaction tank
9 Centrifugal pump
10 Separator
11 Collecting tank
12 Positive displacement pump
13 Tank for ingredients
14 Positive displacement pump
15 Mixing tank
16 Positive displacement pump
17 Precooler
18 Scraped-surface heat exchanger
A Milk feed
B Culture and rennet feed
C Whey discharge
D Cooling medium feed
E Hot packaging
F To packaging
G Displacement water
H Salt addition
I Cooling medium discharge

8. Separators for Soft Cheese Production

8.1 Separator types / rated capacity

The lower section of the bowl is fitted with 6 or 12 nozzles.

Quark (approx.18 % DM)	
Separator type	Rated capacity
KDB 3	200 kg/h
KDB 16	1000 kg/h
KDE 30	2000 kg/h
KDE 45	3000 kg/h
Double cream cheese (approx. 44 % DM)	
Separator type	Rated capacity
KSE 10	1000 kg/h
KSE 30 / KSI* 30	3000 kg/h
KSE 50 / KSI* 50	4500 kg/h

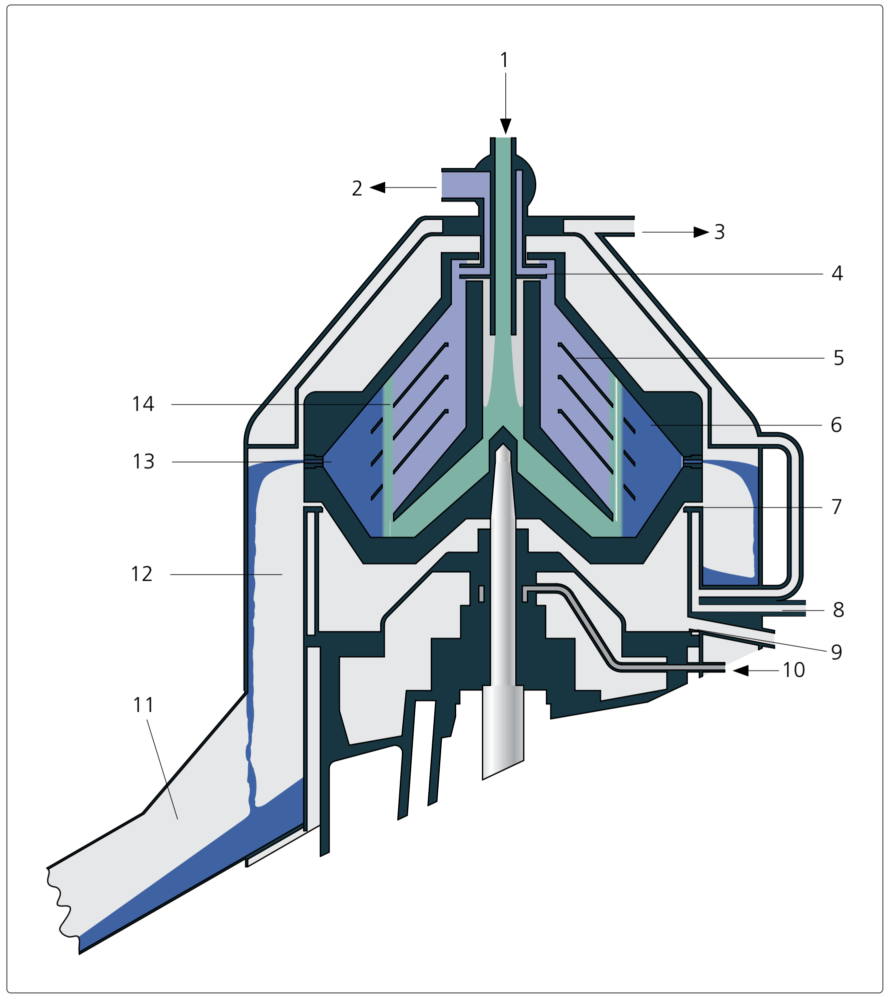
The separator types listed under quark are also suitable for production of Labaneh and cream cheese.

* KSI with new integrated direct drive

8.2 Separators type KDB, KDE

The function of the KDE 30 shown in Figure 18 is described by way of example. The coagulated skim milk flows through the feed (1) into the center of the bowl and via the distributor into the rising channels (14) in the disk stack (5). This is where separation into quark and whey is carried out. The quark separated out in the disk stack is fed to the nozzles through the segmental insert and is then discharged out of the bowl via the concentrate collector (12) into the quark hopper (11). This special design thus provides long holding times and low losses. The whey flows inwards through the disk gap. The residual protein particles are separated out. The centripetal pump (4) fitted in the head of the bowl is used to discharge the whey under pressure (2) without foam.

Fig. 18 Quark separator, type KDE 30



1 Feed
2 Discharge, whey
3 Discharge / cover cooling
4 Centripetal pump, whey
5 Disk stack
6 Segmental insert
7 Brake ring, cooled
8 Feed, concentrate collector and brake ring / hood cooling
9 Discharge, frame
10 Sterile air / CIP connection
11 Discharge to quark hopper
12 Concentrate collector
13 Nozzles
14 Rising channels

The quark hopper is equipped with a level sensor, which regulates the quark pump at different levels.

The quark output is determined by the nozzle diameter. Combining nozzles with differently sized holes enables the separator output to be adapted to specific product requirements in terms of quark quantity and dry matter, within certain limits.

The bowl has nozzles (13) on the outer wall to discharge the quark. The segmental insert (6), consisting of stainless steel segments, prevents protein particles from being deposited inside the bowl. This means that all protein particles centrifuged out in the bowl are fed to the nozzles and discharged as quark. This design enables quark losses due to residue in the bowl to be avoided. At the same time, this allows long production times between necessary chemical cleaning.

To ensure optimum functioning of the KDB and KDE type separators, the required values for the product feed, the whey discharge, the service media, filter combinations and the monitoring and control systems are installed in a single unit (valve block). In addition, the process control for operation and observation can also be integrated here.

The following media are required to operate the system:

Cooling water
The brake ring, the concentrate collector and the hood are cooled by ice water. This prevents caking of the protein particles. In addition, with the exception of the KDB 16, water is required to cool the slide ring packing on the bowl spindle.

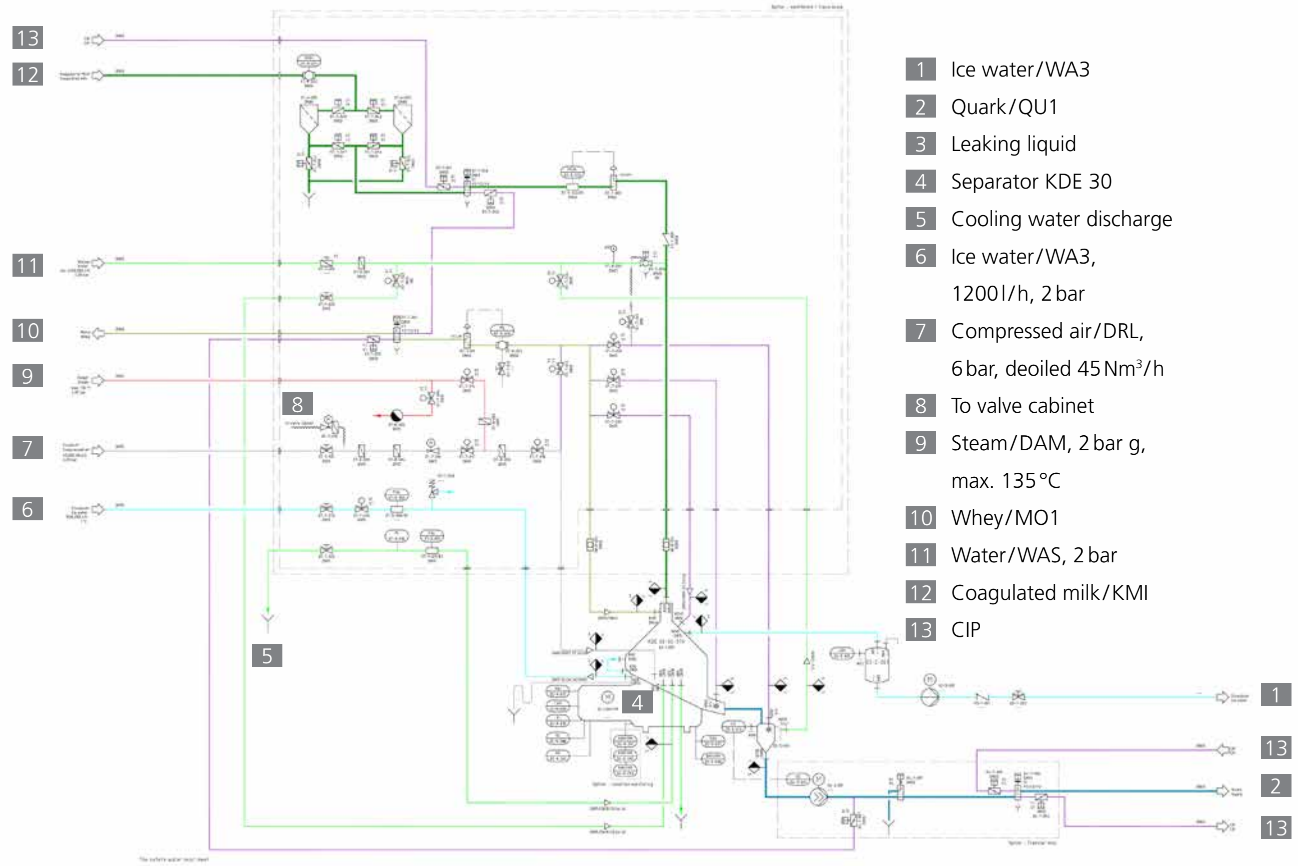
Sterile air
The infeed of sterile air between the bowl and brake ring builds up a slight overpressure in the upper section of the frame. This prevents bacterial contamination from the ambient air.

Steam
The sterile filters for sterile air can be sterilized in line on the KDE 30 and 45 at standstill. On the KDC 30, the entire separator can be sterilized at standstill.

Safety water
During operation, the KDB and KDE types are monitored by a vibration sensor. Vibration monitoring works at 2 stages. At the first stage there is only an alarm. If the second limit value is exceeded, the motor is shut down after a brief delay and the bowl is flooded with safety water. The safety water function prevents the bowl from running out of balance and is also activated if the minimum flow of liquid in the feed is not reached. The safety water must always be available during operation of the separator!

Vacuum
On the KDE 30 and the KDE 45, there is an option of operating the machines in vacuum mode. The sterile air is then discharged from the system at the quark hopper.

Fig. 19 Example PID for a KDE 30



1 Ice water/WA3
2 Quark/QU1
3 Leaking liquid
4 Separator KDE 30
5 Cooling water discharge
6 Ice water/WA3, 1200 l/h, 2 bar
7 Compressed air/DRL, 6 bar, deoiled 45 Nm³/h
8 To valve cabinet
9 Steam/DAM, 2 bar g, max. 135 °C
10 Whey/MO1
11 Water/WAS, 2 bar
12 Coagulated milk/KMI
13 CIP

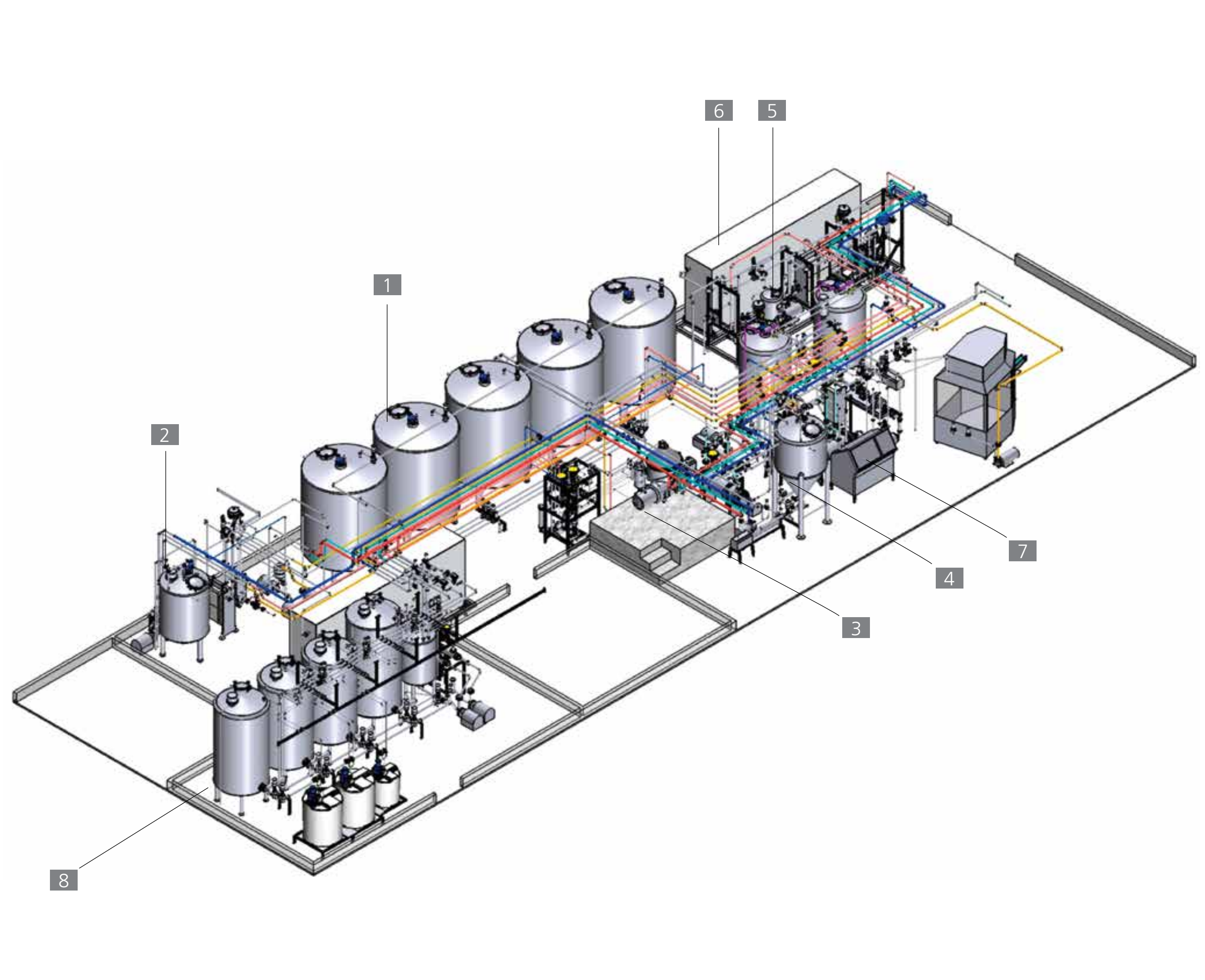


Fig. 20 Complete soft cheese production line from 3D planning

1 Coagulation tanks
2 Thermization
3 Separator
4 Intermediate soft cheese storage
5 Mixing and renneting station
6 Milk pasteurizer
7 Mixing and whipping unit
8 CIP system

8.3 Separators type KSE, KSI

While KSE separators are driven with a maintenance-friendly and economical flat-belt system, the KSI types feature an integrated direct drive which comes with significant benefits in terms of energy consumption and installation space requirement.

The coagulated, standardized milk is fed into the center of the bowl through the feed tube (1). From there, the milk is fed through the distributor into the rising channels (9) in the disk stack (6). This is where it is separated into cheese and whey. The whey flows out through the disk gap. The remaining protein fat particles are separated. The whey passes via the separating disk (10) into the upper centripetal pump chamber and is discharged under pressure without foam by the centripetal pump (4). Due to the high fat content, the cheese is in the light phase and flows inwards, which raises its concentration. The cheese flows into the lower centripetal pump chamber via a dam (regulating ring). The concentrate centripetal pump (5) conveys the cheese to the discharge (2). The dry matter content in the cheese is adjusted using a valve at the whey discharge (3). Increasing the discharge pressure forces more cheese out of the bowl and the dry matter content falls. To increase the dry matter, the discharge pressure of the whey has to be reduced. During production, a small proportion of free protein (not sufficiently wetted with fat) accumulates in the solid chamber (7). This protein is discharged by partial ejection at intervals of 1 – 2 hours. A sight glass is installed in the whey discharge line (3) to monitor proper separation. Opaque whey indicates that partial ejection should be performed. If there is no improvement, the parameters such as separating temperature, vat milk treatment and dry matter in the cheese should be checked.

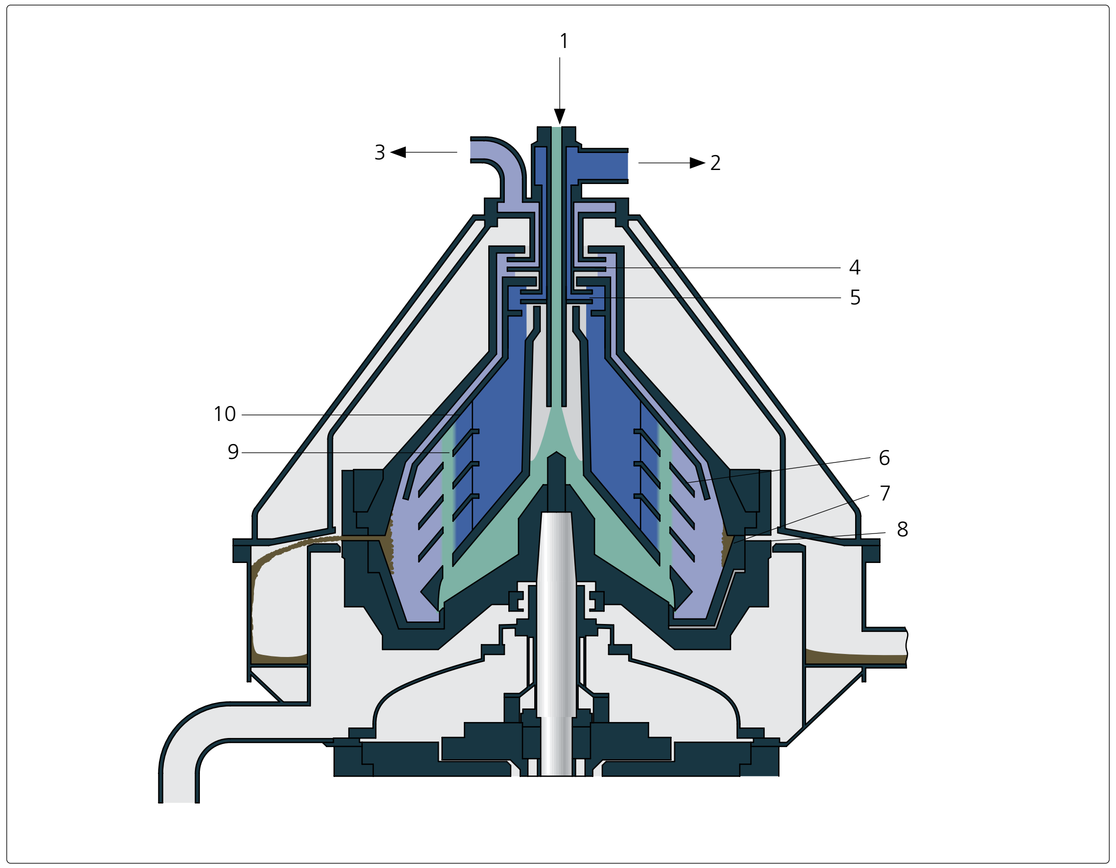


Fig. 21 Bowl cross-section of a KSE 50 separator

1 Feed
2 Discharge, cheese
3 Discharge, whey
4 Centripetal pump, whey
5 Centripetal pump, cheese (protein-fat particles)
6 Disk stack
7 Solid chamber
8 Solids discharge gap
9 Rising channels
10 Separating disk

9. Control Units for Soft Cheese Production Lines

Control and monitoring of soft cheese separators and the entire process lines for producing soft cheese are constantly gaining in importance. For this reason, in recent years GEA has been continuously developing products ranging from compact control units for decentralized tasks to central control stations. These feature programmable logic controllers (PLCs) with process visualization and operation (HMI).

Process automation is achieved using a PLC. This processes the binary and analogue control signals and performs control tasks and complex computing operations. The PLC is influenced by signals from encoders and sensors within the system and by process parameters. The PLC processes the information cyclically and uses actuators to influence the process. The process is constantly supervised and monitored and any variations in parameters or faults trigger an immediate response. The PLC, designed for classic automation tasks, operates as an autarkic controller. It can be linked to higher-level controllers to exchange signals. This connection is a data interface provided by a bus system (Profibus, Ethernet etc.).

On smaller systems, process visualization takes the form of a local screen on which the process and the key parameters are clearly displayed. On medium to large systems, a PC-based operating system is used for process visualization. On one or more monitors, the process and all parameters are displayed using an appropriate number of screens. Control loops, trends and alarm messages are displayed and saved for a longer period. Communication with a master computer for acquisition of production data is standard and can be adapted to specific customer requirements.

In all systems, the control panel allows intervention in the process at all times. This allows parameters and specified values to be changed, actuators to be operated and the process started, paused or stopped. Alarm messages and process values can be output on a printer.

High performance, state of the art technology provides the high level of flexibility required to meet the increasing demands for automation, brings transparency to the process, contributes to increased productivity while simultaneously improving quality and reduces production costs.

In addition to the PLC itself, to ensure convenient and intuitive operation and observation a plant automation solution requires efficient interfaces between the plant and the operator. This is the only way to meet the increasing demands for automation technology and achieve a high level of flexibility. Even the best machines and plants only run optimally if they are supported by an equally effective partner on the control side. For this reason, there is a need for expert, individual solutions that can satisfy the most rigorous quality standards.

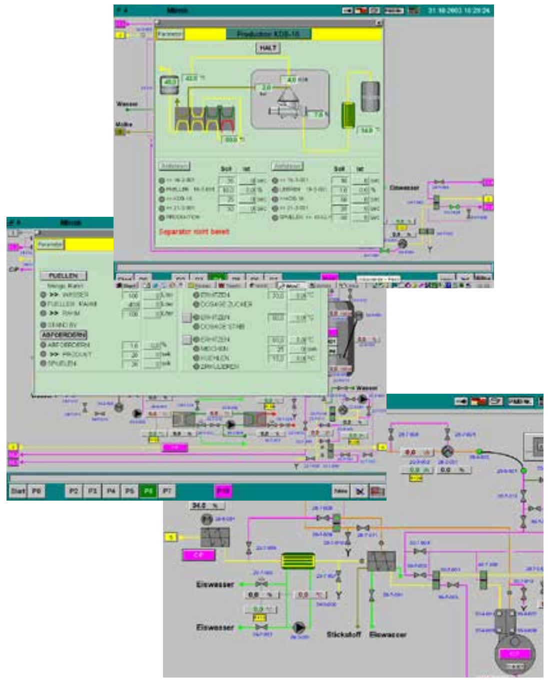


Fig. 22 Screenshots from the visualization for an entire process line

10. Control of Soft Cheese Dry Matter

An important factor in efficient quark production with separators is ensuring a consistent dry matter.

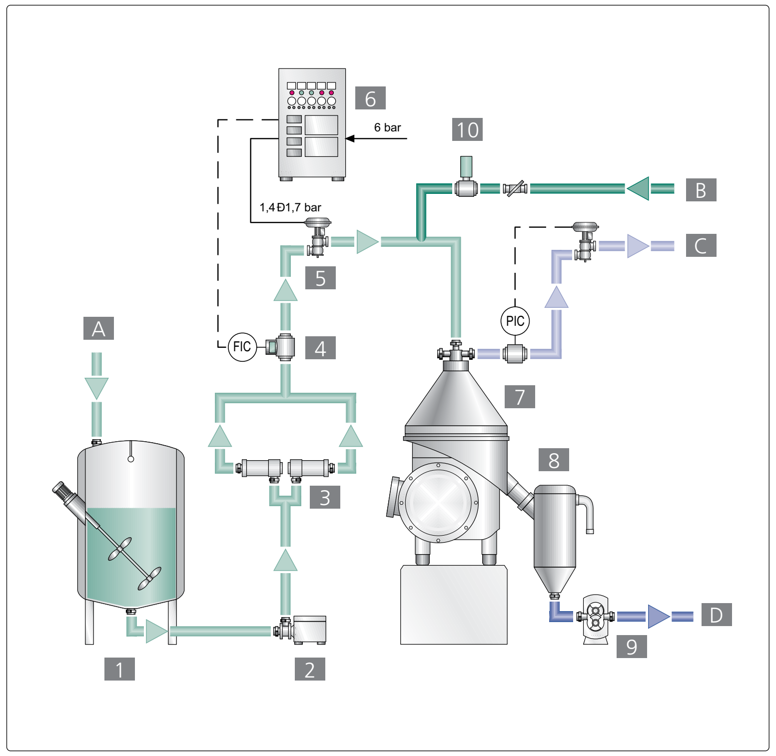
Main influencing factors:

- Uniform composition of the vat milk
- Constant feed to separator

There are not normally any differences in the vat milk composition. However, there may be slight variations between the different coagulation tanks, which automatic regulation of the dry matter can take account of. Differences between individual coagulation tanks are spread over long periods of time by using feed tanks of sufficient dimensions. To ensure consistent separation, apart from continuous process control, it is important to prevent possible clogging of the nozzles by optimum preliminary filtering. The constant feed to the separator is achieved by using an automatic flow control system.

Regulation works like this:
The quantity flowing to the separator is measured by an inductive flowmeter (4). After comparing the specified and actual values, the controller adjusts a regulator valve (5) installed at the separator feed. The required quantity then remains constant, e. g. even if there are fluctuations in the feed resulting from changes in the admission pressure from the upstream system.

Analysis can be done in-line or in the laboratory. The in-line values can be used in the control system as additional corrective factors.



1 Balance tank
2 Centrifugal pump
3 Tubular strainer (reversible)
4 Inductive flowmeter
5 Control valve (automatic)
6 Control cabinet
7 Soft cheese separator
8 Soft cheese hopper
9 Positive displacement pump
10 Water valve

A Skim milk feed
B Water feed
C Whey discharge
D Soft cheese discharge

Fig. 23 Electro-pneumatic feed control

11. Mixing Quark with Additives

In Germany and many other countries, there is an upwards trend for quark products. New product variations are constantly forcing their way into the market and achieving acceptance among consumers. As well as standard quark with different fat content, the product range includes various quark products with herbs, fruit preparations and whipped products.

The quality of quark products is determined by:

- Appearance
- Aroma
- Taste
- Consistency
- Shelf life

These quality requirements depend on a number of factors, including mixing. The better the flavorings and aromas are distributed, the greater the taste and aroma experience for the consumer.

A slight influence on internal product texture due to mechanical stress is also reducing the risk of undesired syneresis, or loss of viscosity. These days, there is a need for self-contained mixing systems, which enable the risk of bacteriological influence and thus impairment of the shelf life to be reduced. At the same time, they can prevent ambient air from influencing the product, which would lead to oxidation processes and thus to organoleptic changes. The aim of every mixing process is to bring or combine the particles of a substance consisting of several components into a uniform, physically cohesive whole.

11.1 Continuous in-line mixing

With in-line mixing, all components to be added are incorporated into the continuously flowing stream of product at one point.

The mixing process therefore involves targeted transportation of particles. The required energy is provided mechanically in the dynamic mixer. Dynamic mixers are used for continuous mixing of quark with cream, fruits, spices etc.

The following parameters are vital for successful continuous mixing of full-fat quark:

- The dry matter of the low-fat quark must be constant.
- The feed rate of the quark and cream pump to the mixer must be constant.

Optimum provision of the required metering quantities of cream, fruit concentrate etc. can be achieved using the dosing station shown in fig. 24. Frequency-controlled positive displacement pumps (5, 8, 11) are used to convey the individual components. The specified mixing ratio is set using ratio control.

The pump (2) conveys the quark from the silo (1) to the mixer (14).

An inductive flowmeter (3) continuously measures the quark flow.

The components to be added, such as cream, fruit concentrate etc., are also measured using an inductive flowmeter and added to the quark at the specified ratio.

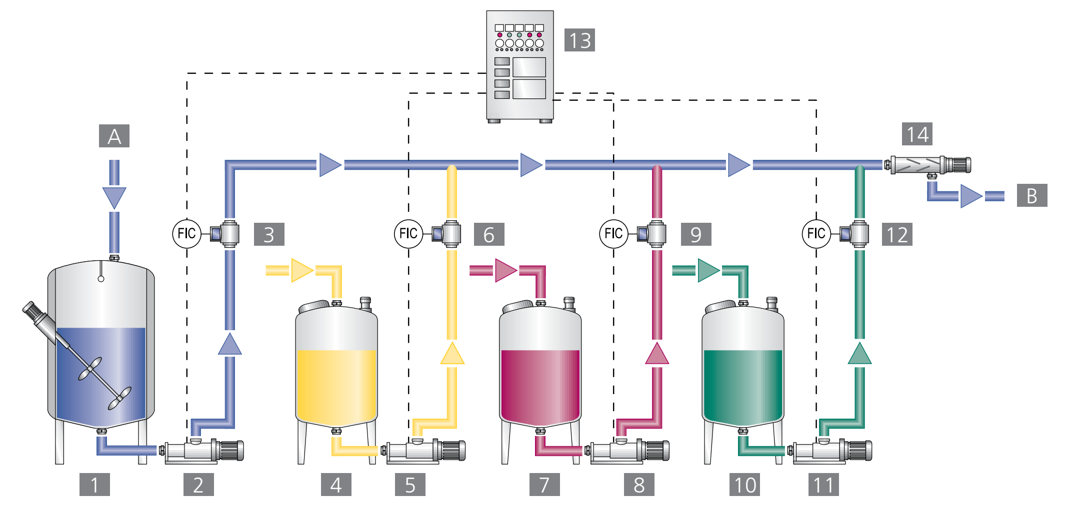


Fig. 24 Mixing quark

- 1 Quark silo
- 2 Positive displacement pump
- 3 Inductive flowmeter
- 4 Tank for cream
- 5 Positive displacement pump
- 6 Inductive flowmeter
- 7 Fruit tank
- 8 Positive displacement pump
- 9 Inductive flowmeter
- 10 Tank
- 11 Positive displacement pump
- 12 Inductive flowmeter
- 13 PLC and MCC
- 14 Quark mixer
- A Quark feed
- B Quark discharge

11.2 Semi-continuous mixing

In certain cases, it makes sense to perform an external mixing process in silos. The design of the mixing station guarantees a semi-continuous production process. This solution is generally used where ingredients such as spices, fruit pieces or dry substances have to be mixed. Particularly for spices and dry substances, a longer reaction time is needed to achieve a perfect texture in the soft cheese.

Fig. 24 shows an example of a mixing station. The cooled quark (approx. 18 °C) is stored in the silo (1). The positive displacement pump (2) first conveys the quark into the relevant mixing tank (3) as the main component. To achieve an optimum mixing ratio, the mixing tank (3) can be equipped with computer-controlled load cells.

The other components, e. g. cream from tank (6), fruit concentrate from tank (8) and stabilizers from tank (4) are then added to the main component (quark) inline at the appropriate percentage.

When the metering process is complete, the mixing process begins. To guarantee continuous operation in cooling and packaging, the filling and mixing processes are performed alternately on the first and second mixing tank (3). The finished product is then conveyed to the cooling and packaging station by the pump (10).

11.2.1 Addition of stabilizers

The reasons for the use of stabilizers (hydrocolloids) in quark production include "extending the shelf life under demanding conditions".

The choice of suitable stabilizers for quark preparations should always be based on the relevant end product. The following criteria need to be considered:

- Hygienic quality
- Neutral taste
- Good dispersibility
- Stability under physical, chemical and biological influences
- Resistance to thermal shocks

The effect of stabilizers differs greatly and depends on numerous factors, such as the pH value and the heating temperature.

For quark preparations, the following functions generally need to be provided:

- Supporting emulsification
- Prevention of syneresis
- Protective colloid effect for thermal treatment
- Foam stability
- Maintenance of full flavor
- Improving consistency by increasing viscosity

Due to the complexity of the problems that can occur as a result of using stabilizers, it is important to consider this when planning the whole system.

For example, depending on the selected stabilizer type, the specified temperature must be exactly maintained during storage and metering. This calls for additional loop circuits in the system, e. g. for stoppages etc.

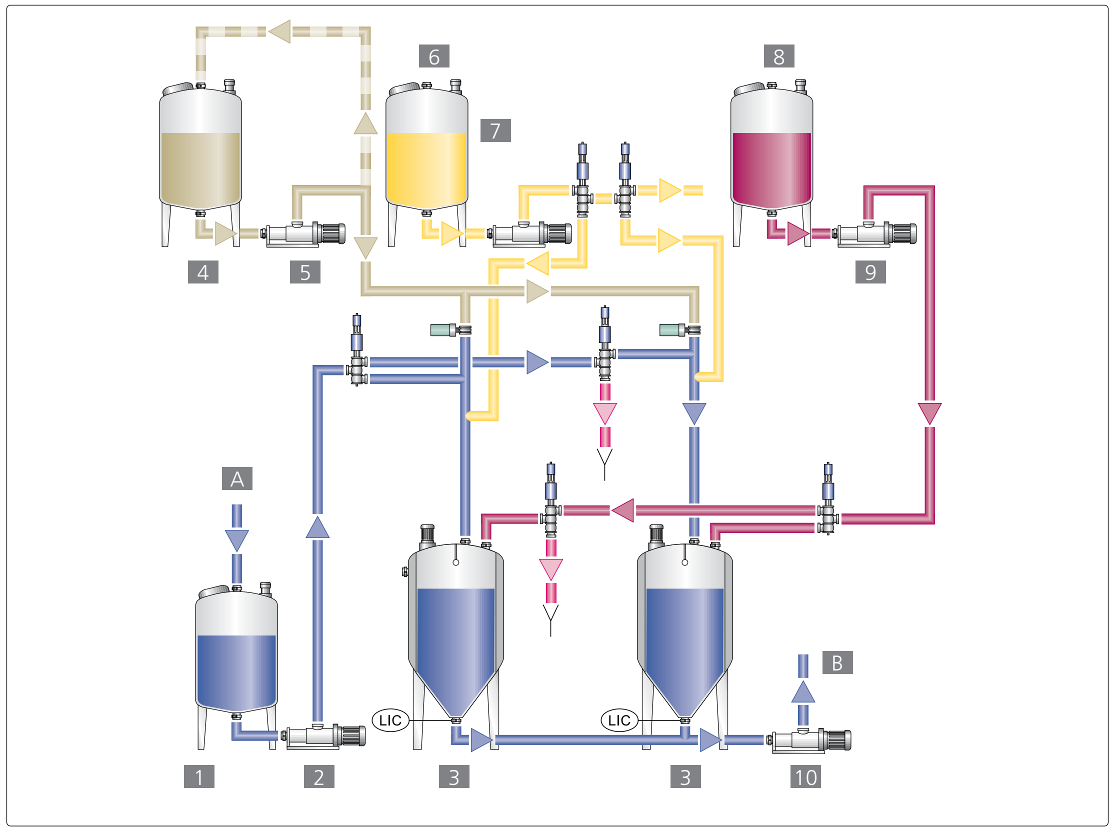


Fig. 25 Semi-continuous silo mixing station

1 Quark silo
2 Positive displacement pump
3 Mixing tank
4 Tank for stabilizer
5 Positive displacement pump
6 Cream tank
7 Positive displacement pump
8 Tank for fruit concentrate
9 Positive displacement pump
10 Positive displacement pump
A Soft cheese from separator
B Soft cheese for thermization

12. Cooling Soft Cheese

As well as the bacteriological properties of the product, effective cooling is also essential to ensure that standard quark has the longest possible shelf life.

When it comes to cooling viscous products like quark, the following factors need to be considered when selecting the cooler system to be used:

A Use of plate heat exchangers

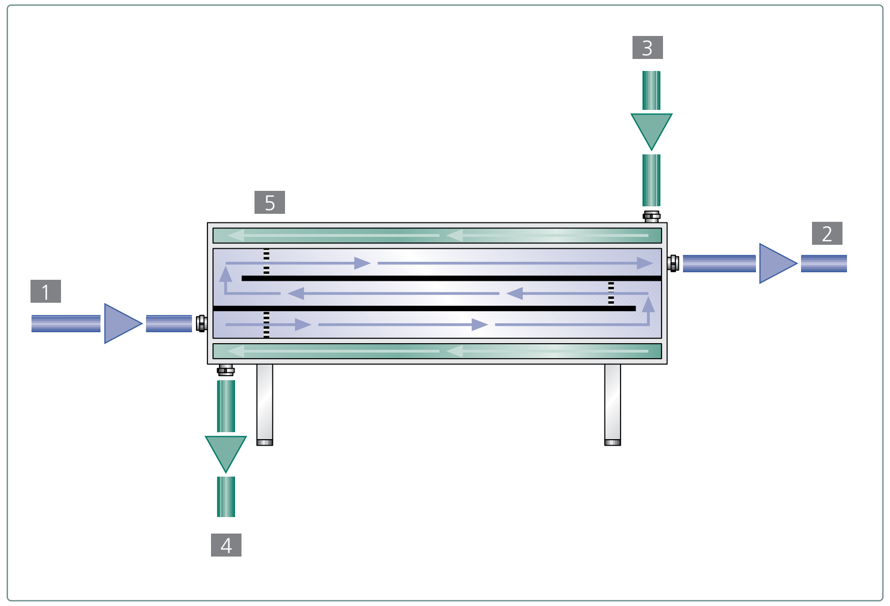
- With parallel setup of cooling surfaces, it must be ensured that there is still sufficient flow in each individual gap. Otherwise, some of the channels can become clogged, causing the cooling capacity to be reduced. In addition, chemical cleaning must be carried out with very high flow rates.
- With series connection of cooling surfaces, the cooling effect is always good. However, the long distance means that the pressure loss in the cooler is relatively high and a high feed rate must thus be used. At the same time, applying a high pressure, > 10 bar, to the quark may result in damage to its structure, e. g. enhanced syneresis tendency.
- For the above reasons, plate heat exchangers can be used for quark with a low overall dry matter.

B Cooling quark using tubular coolers

12.1 Product cooling using tubular coolers

For some years GEA has generally used three-pass tubular coolers for cooling standard quark. The quark is conveyed through the cooler with a positive displacement pump. The advantage of the three-pass design is that the quark is stirred at the two reversal points. This means that uncooled layers of quark reach the cooling surface on the next pass. The cooling medium is a counter flow of ice water conveyed through the cooler.

The tubular cooler is fitted with a baffle in the feed to every individual tube bundle. This forces the quark to be distributed evenly across all tubes.



1 Product feed
2 Product discharge
3 Ice water feed
4 Ice water discharge
5 Perforated disk

Fig. 26 Schematic view of tubular cooler

12.1.1 2-stage cooling

With this process, the quark is cooled from 40 °C to around 16 °C at the first stage and then stored in the silo at this temperature. Cream and fruits are then mixed in after the second cooling process, directly before the packaging machine, as the fat reduces the cooling capacity.

The quark is not yet a firm structure at 16 °C and can be pumped off from the silo with no fluctuations in output. At the second cooling stage, the quark is cooled from 16 °C to between 5 and 6 °C. It is then packaged at this temperature. This is the optimum solution for a long shelf life.

12.2 Use of scraped-surface heat exchanger

If, for bacteriological reasons for example, quark mixtures are to be pasteurized, scraped-surface heat exchangers should be used for heating to the pasteurizing temperature (> 70 °C) and scraped-surface heat exchanger for cooling to the packaging temperature.

This also applies to cooling cream or double cream cheese and Labneh to temperatures of < 40 °C. If high temperature differences from 70 °C to 40 °C are anticipated, a tubular cooler should be installed upstream of the scraped-surface heat exchanger for energy reasons.

At product temperatures below 40 °C, the fat partially crystallizes, which causes the heat exchange surfaces to "stick". The use of rotating scrapers thus provides continuous cleaning of the heat exchange surfaces. A variable scraper shaft drive optimizes the mechanical stress on the product.

A crucial feature of scraped-surface heat exchangers – in contrast to other cooling systems – is the low pressure consumption, even at temperatures of around 10 °C. The discharge losses must be taken into account. As the design of the entire cooling system depends greatly on the coolant type, this should be clearly defined for each individual application. Ice water, glycol or ammonia are normally used as coolants.

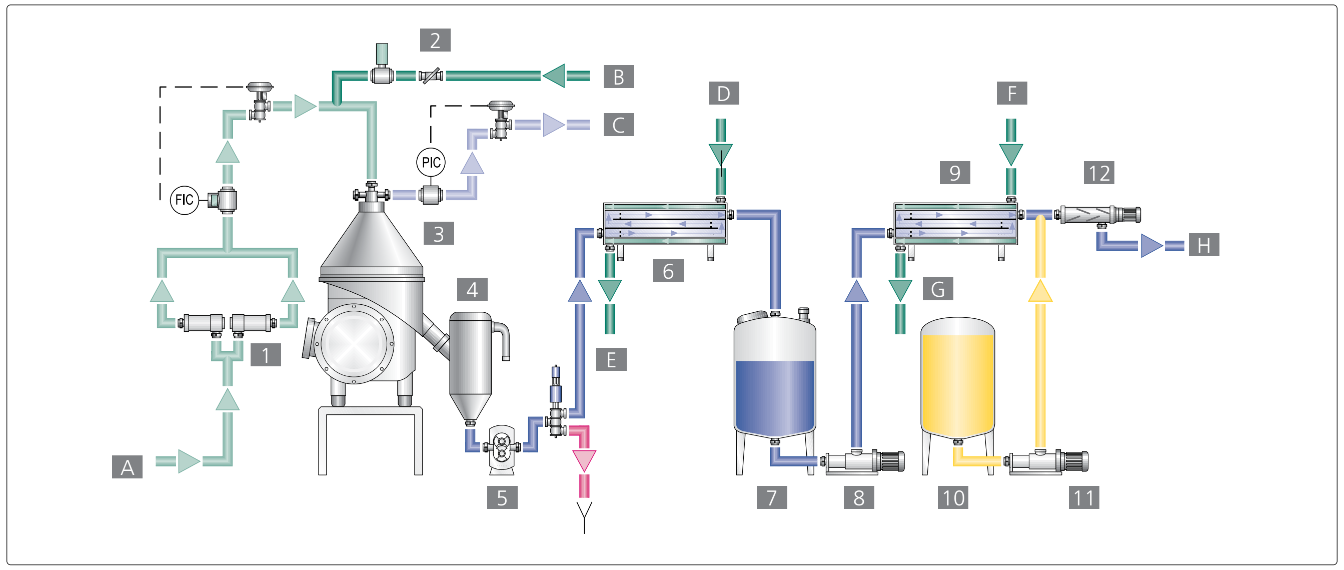


Fig. 27 2-stage cooling of quark

1 Tubular strainer (reversible)
2 Tubular strainer
3 Quark separator
4 Quark hopper
5 Positive displacement pump
6 Quark cooler
7 Quark silo
8 Positive displacement pump
9 Quark cooler
10 Tank for cream
11 Positive displacement pump
12 Quark mixer
A Skim milk feed
B Water feed
C Whey discharge
D Ice water feed
E Ice water discharge
F Ice water feed
G Ice water discharge
H To packaging

13. Chemical Cleaning of Soft Cheese Lines (CIP)

All soft cheese separators and lines from GEA can be chemically cleaned (CIP – cleaning in place). Due to the different separator designs, a variety of different cleaning processes are used.

13.1 MIA 20 cleaning system

A special CIP process is required for automatic chemical cleaning of KDB type separators. A decentralized cleaning unit allows optimum, independent in-line cleaning directly after production. The MIA 20 cleaning system is available for this purpose.

Chemical cleaning of the separators is based on a special cleaning program.

Fig. 28 The MIA system fully meets the specific requirements for cleaning quark separators

After production, the system is changed over to chemical cleaning mode. It must be ensured that the separator is always filled with water during this time.

Cleaning is then performed using the following schedule:

- 5 minutes rinsing with water
- 25 minutes alkali circulation at approx. 50 °C
- 15 minutes alkali circulation at approx. 75 – 80 °C
- Repeated draining and refilling of the bowl (shocking)
- 10 minutes acid circulation 50 – 60 °C
- Repeated draining and refilling of the bowl (shocking)
- Rinsing the system with water

A quark system can also be cleaned using a central CIP system. However, it is important to ensure that the program meets the specified standards.

The prerequisites for effective operation of the cleaning system are:

- The CIP program must comply with the Group recommendations
- Alkali and acid concentrations meet the requirements
- Cleaning agents must be free of sediment and suspended particles if re-used. If not, we recommend pre-cleaning using a filter.

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"Engineering for a better world" is the driving and energizing principle connecting GEA's workforce. As one of the largest systems suppliers, GEA makes an important contribution to a sustainable future with its solutions and services, particularly in the food, beverage and pharmaceutical sectors. Across the globe, GEA's plants, processes and components contribute significantly to the reduction of CO_2 emissions, plastic use as well as food waste in production.

GEA is listed on the German MDAX and the STOXX® Europe 600 Index and also included in the DAX 50 ESG and MSCI Global Sustainability indexes.

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