CHAPTER-III

INTRODUCTION TO DAIRY PROCESSING

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CHAPTER-III
INTRODUCTION TO DAIRY PROCESSING

Milk is an important food with many nutrients. Milk production began 6,000 years ago or even earlier. The dairy animals of today have been developed from untamed animals which, through thousands of years, lived at different altitudes and latitudes exposed to natural and, many times, severe and extreme conditions. The principal constituents of milk are water, fat, proteins, lactose (milk sugar) and minerals (salts). Milk also contains trace amounts of other substances such as pigments, enzymes, vitamins, phospholipids (substances with fatlike properties), and gases. The composition analysis of Milk, per 100 grams is as follows

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Unit</th>
<th>Cow</th>
<th>Goat</th>
<th>Sheep</th>
<th>Water buffalo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>G</td>
<td>87.8</td>
<td>88.9</td>
<td>83</td>
<td>81.1</td>
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<tr>
<td>Protein</td>
<td>G</td>
<td>3.2</td>
<td>3.1</td>
<td>5.4</td>
<td>4.5</td>
</tr>
<tr>
<td>Fat</td>
<td>g</td>
<td>3.9</td>
<td>3.5</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>g</td>
<td>4.8</td>
<td>4.4</td>
<td>5.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Energy</td>
<td>kcal</td>
<td>66</td>
<td>60</td>
<td>95</td>
<td>110</td>
</tr>
<tr>
<td>Sugars (lactose)</td>
<td>g</td>
<td>4.8</td>
<td>4.4</td>
<td>5.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>mg</td>
<td>14</td>
<td>10</td>
<td>11</td>
<td>8</td>
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<tr>
<td>Calcium</td>
<td>mg</td>
<td>120</td>
<td>100</td>
<td>170</td>
<td>195</td>
</tr>
<tr>
<td>Saturated fatty acids</td>
<td>g</td>
<td>2.4</td>
<td>2.3</td>
<td>3.8</td>
<td>4.2</td>
</tr>
<tr>
<td>Monounsaturated fatty acids</td>
<td>g</td>
<td>1.1</td>
<td>0.8</td>
<td>1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Polyunsaturated fatty acids</td>
<td>g</td>
<td>0.1</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
</tr>
</tbody>
</table>

(Source: USDA National Nutrient Database for Standard Reference., Arc.usda.gov)

Emulsion is a suspension of droplets of one liquid in another. Milk is an emulsion of fat in water, butter emulsion of water in fat. The finely divided liquid is known as the dispersed phase and the other as the continuous phase. Milk and cream are examples of fat-in-water (or oil-in-water) emulsions. The milk fat exists as small globules or droplets dispersed in the milk serum, If milk is left to stand for a while in a vessel, the fat will rise and form a layer of cream on the surface.
Classes of milk proteins

Milk contains hundreds of types of protein, most of them in very small amounts. The old way of grouping milk proteins into casein, albumin and globulin has given way to a more adequate classification system. Minor protein groups have been excluded for the sake of simplicity. Whey protein is a term often used as a synonym for milk-serum proteins, but it should be reserved for the proteins in whey from the cheese making process. In addition to milk-serum proteins, whey protein also contains fragments of casein molecules. Some of the milk-serum proteins are also present in lower concentrations than in the original milk. This is due to heat.

Enzymes in milk

Enzymes are a group of proteins produced by living organisms. They have the ability to trigger chemical reactions and to affect the course and speed of such reactions. Lactose is a sugar found only in milk; it belongs to the group of organic chemical compounds called carbohydrates. Carbohydrates are the most important energy source in our diet. Carbohydrates also supply material for the synthesis of some important chemical compounds in the body. They are present in muscles as muscle glycogen and in the liver as liver glycogen.

Vitamins in milk

Vitamins are organic substances which occur in very small concentrations in both plants and animals. They are essential to normal life processes. Milk contains many vitamins. Among the best known are A, B1, B2, C and D. Vitamins A and D are soluble in fat, or fat solvents, while the others are soluble in water.

Minerals and salts in milk

Milk contains a number of minerals. The total concentration is less than 1%. Mineral salts occur in solution in milk serum or in casein compounds. The most important salts are those of
calcium, sodium, potassium and magnesium. They occur as phosphates, chlorides, citrates and caseinates. Potassium and calcium salts are the most abundant in normal milk. The amounts of salts present are not constant. Towards the end of lactation, and even more so in the case of udder disease, the sodium chloride content increases and gives the milk a salty taste, while the amounts of other salts are correspondingly reduced.

**Other Constituents of milk**

Milk always contains somatic cells (white blood corpuscles or leucocytes). The content is low in milk from a healthy udder, but increases if the udder is diseased, usually in proportion to the severity of the disease. The somatic cell content of milk from healthy animals is as a rule lower than 200 000 cells/ml, but counts of up to 400 000 cells/ml can be accepted. Milk also contains gases, some 5 – 6 % by volume in milk fresh from the udder, but on arrival at the dairy the gas content may be as high as 10 % by volume. The gases consist mostly of carbon dioxide, nitrogen and oxygen. They exist in the milk in three states:

1. dissolved in the milk
2. bound and non-separable from the milk
3. dispersed in the milk

Dispersed and dissolved gases are a serious problem in the processing of milk, which is liable to burn on to heating surfaces if it contains too much gas. Several important factors need to be taken into consideration in the design of food processing plants in order to assure the quality of the end products. One of them is the question of rheology. In the dairy industry, in particular, there are cream and cultured milk products whose characteristics can be partially or completely spoiled if their flow behaviour is not understood.

**Keeping the milk cool**

The milk should be chilled to below + 4°C immediately after milking and be kept at this temperature all the way to the dairy. If the cold chain is broken somewhere along the way, e.g. during transportation, the micro-organisms in the milk will start to multiply. This will
result in the development of various metabolic products and enzymes. Subsequent chilling will arrest this development, but the damage has already been done. The bacteria count is higher and the milk contains substances that will affect the quality of the end product.

Design of farm dairy premises

The first step in preserving the quality of milk must be taken at the farm. Milking conditions must be as hygienic as possible; the milking system designed to avoid aeration, the cooling equipment correctly dimensioned. To meet the hygienic requirements, dairy farms have special rooms for refrigerated storage. Bulk cooling tanks are also becoming more common.

Delivery to the dairy

The raw milk arrives at the dairy in churns or in insulated road tankers, the latter being used only in combination with bulk cooling tanks at the farm. The requirements are the same for both methods – the milk must be kept well chilled and free from air and treated as gently as possible. For example, churns and tanks should be well filled in order to prevent the milk from sloshing around in the container.

Testing milk for quality

Milk from sick animals and milk which contains antibiotics or sediment must not be accepted by the dairy. Even traces of antibiotics in milk can render it unsuitable for the manufacture of products which are acidified by the addition of bacteria cultures, e.g. yoghurt and cheese. Normally only a general assessment of the milk quality is made at the farm. The composition and hygienic quality is usually determined in a number of tests on arrival at the dairy. The outcome of some of these tests has a direct bearing on the money paid to the farmer.
Milk reception

Dairies have special reception departments to handle the milk brought in from the farms. The first thing done at reception is to determine the quantity of the milk. The quantity is recorded and entered into the weighing system that the dairy uses to weigh the intake and compare it with the output. The quantity of the intake can be measured by volume or by weight.

Chilling the incoming milk

Normally a temperature increase to slightly above +4 °C is unavoidable during transportation. The milk is therefore usually cooled to below +4 °C in a plate heat exchanger before being stored in a silo tank to await processing.

Raw milk storage

The untreated raw milk – whole milk – is stored in large vertical tanks – silo tanks – which have capacities from about 25 000 litres up to 150 000 litres. Normally, capacities range from 50,000 to 1,00,000 litres. Smaller silo tanks are often located indoors while the larger tanks are placed outdoors to reduce building costs. Outdoor silo tanks are of double-wall construction, with insulation between the walls. The inner tank is of stainless steel, polished on the inside, and the outer wall is usually of welded sheet metal.

The purposes of heat treatment

By the end of the 19th century, heat treatment of milk had become so commonplace that most dairies used the process for some purpose or another, such as for milk intended for cheese and butter production. Before heat treatment was introduced, milk was a source of infection, as it is a perfect growth medium for micro-organisms. Diseases such as tuberculosis and typhus were sometimes spread by milk. The term “pasteurisation” commemorates Louis Pasteur, who in the middle of the 19th century made his fundamental studies of the lethal effect of heat on micro-organisms and the
use of heat treatment as a preservative technique. The pasteurisation of milk is a special type of heat treatment which can be defined as “any heat treatment of milk which secures the certain destruction of tubercle bacillus (T.B.) without markedly affecting the physical and chemical properties”. Fortunately, all common pathogenic organisms likely to occur in milk are killed by relatively mild heat treatment which has only a very slight effect on the physical and chemical properties of milk. The most resistant organism is the tubercle bacillus (T.B.), which is considered to be killed by heating milk to 63°C for 10 minutes. Complete safety can be assured by heating milk to 63°C for 30 minutes. T.B. is therefore regarded as the index organism for pasteurisation: any heat treatment which destroys T.B. can be relied upon to destroy all other pathogens in milk.

Limiting factors for heat treatment

Intense heat treatment of milk is desirable from the microbiological point of view. But such treatment also involves a risk of adverse effects on the appearance, taste and nutritional value of the milk. Proteins in milk are denatured at high temperatures. This means that the cheesemaking properties of milk are drastically impaired by intense heat treatment. Intense heating produces changes in taste; first cooked flavour and then burnt flavour. The choice of time/temperature combination is therefore a matter of optimization in which both microbiological effects and quality aspects must be taken into account. Since heat treatment has become the most important part of milk processing, and knowledge of its influence on milk better understood, various categories of heat treatment have been initiated.

Thermisation

In many large dairies it is not possible to pasteurise and process all the milk immediately after reception. Some of the milk must be stored in silo tanks for hours or days. Under these conditions, even deep chilling is not enough to prevent serious quality deterioration. Many dairies therefore preheat the milk to a temperature below the pasteurisation temperature to temporarily inhibit bacterial growth. This process is called
thermisation. The milk is heated to 63 – 65°C for about 15 seconds, a time/temperature combination that does not inactivate the phosphatase enzyme. Double pasteurisation is forbidden by law in many countries, so thermisation must stop short of pasteurisation conditions.

Lethal effect on bacteria.

UHT treatment

UHT is the abbreviation for Ultra High Temperature. UHT treatment is a technique for preserving liquid food products by exposing them to brief, intense heating, normally to temperatures in the range of 135 – 140°C. This kills micro-organisms which would otherwise destroy the products. UHT treatment is a continuous process which takes place in a closed system that prevents the product from being contaminated by airborne micro-organisms. The product passes through heating and cooling stages in quick succession. Aseptic filling, to avoid reinfection of the product, is an integral part of the process. Two alternative methods of UHT treatment are used:

• Indirect heating and cooling in heat exchangers,
• Direct heating by steam injection or infusion of milk into steam and cooling by expansion under vacuum.

Sterilisation

The original form of sterilisation, still used, is in-container sterilisation, usually at 115 – 120°C for some 20 – 30 minutes. After fat standardisation, homogenisation and heating to about 80°C, the milk is packed in clean containers – usually glass or plastic bottles for milk, and cans for evaporated milk. The product, still hot, is transferred to autoclaves in batch production or to a hydrostatic tower in continuous production.
Preheating

Normally the desired processing temperatures are reached directly after pasteurisation, but sometimes it is necessary to cool and store the milk temporarily, before the final processing is done. Some examples are given below.

Cheese milk is preheated to 30 – 35°C prior to the vat, where a final temperature adjustment is made before the rennet is added. Hot water is used as the heating medium. Warm whey from a previous batch can also be utilised for a first preheating step, in order to cut the heating costs. Yoghurt milk is preheated to 40 – 45°C prior to the fermentation tank, where the addition of culture takes place. Hot water is used as the heating medium. Milk can also be preheated before addition of other ingredients, like chocolate powder, sugar, fats, etc., needed in different milk-based food products.

Continuous centrifugal separation of milk Clarification

In a centrifugal clarifier, the milk is introduced into the separation channels at the outer edge of the disc stack, flows radially inwards through the channels towards the axis of rotation and leaves through the outlet at the top.

Centrifugal separators

A newly invented appliance for separating cream from milk was described in the German trade journal “Milch-Zeitung” dated the 18th of April 1877. This was “a drum which is made to rotate and which, after turning for a time, leaves the cream floating on the surface so that it can be skimmed off in the usual fashion”. The machine can be linked to a drum which is driven round by a belt and pulley. The cream, which is lighter than the milk, is driven by centrifugal force to the surface of the milk and flows off into a channel from which it is led into a collection vessel; under it, the milk is forced out to the periphery of the drum and is collected in another channel whence it is led to a separate collecting vessel. Today most makes of similar machines are equipped with conical disc stacks. The milk is
introduced through vertically aligned distribution holes in the discs at a certain distance from the edge of the disc stack. Under the influence of centrifugal force the sediment and fat globules in the milk begin to settle radially outwards or inwards in the separation channels, according to their density relative to that of the continuous medium (skim milk). As in the clarifier, the high-density solid impurities in the milk will quickly settle outwards towards the periphery of the separator and collect in the sediment space. Sedimentation of solids is assisted by the fact that the skim milk in the channels in this case moves outwards towards the periphery of the disc stack. The cream, i.e. the fat globules, has a lower density than the skim milk and therefore moves inwards in the channels, towards the axis of rotation. The cream continues to an axial outlet. The skim milk moves outwards to the space outside the disc stack and from there through a channel between the top of the disc stack and the conical hood of the separator bowl to a concentric skim milk outlet.

**Skimming efficiency**

The amount of fat that can be separated from milk depends on the design of the separator, the rate at which the milk flows through it, and the size distribution of the fat globules. The smallest fat globules, normally < 1 µm, do not have time to rise at the specified flow rate but are carried out of the separator with the skim milk. The remaining fat content in the skim milk normally lies between 0.04 and 0.07%, and the skimming ability of the machine is then said to be 0.04 –0.07.

**Fat content of cream**

The whole milk supplied to the separator is discharged as two flows, skimmilk and cream, of which the cream normally represents about 10% of the total throughput. The proportion discharged as cream determines the fat content of the cream.
Control of the fat content in cream

Paring disc separator

The volume of cream discharged from the paring disc separator is controlled by a throttling valve in the cream outlet. Progressively larger amounts of cream, with a progressively diminishing fat content, will be discharged from the cream outlet if the valve is gradually opened.

Standardisation of fat content in milk and cream

Principle calculation methods for mixing of products

Standardisation of fat content involves adjustment of the fat content of milk, or a milk product, by addition of cream or skim milk as appropriate to obtain a given fat content. Various methods exist for calculating the quantities of products with different fat contents that must be mixed to obtain a given final fat content. These cover mixtures of whole milk with skim milk, cream with whole milk, cream with skim milk and skim milk with anhydrous milk fat (AMF).

Direct in-line standardisation

In modern milk processing plants with a diversified product range, direct inline standardisation is usually combined with separation. Previously the standardisation was done manually, but, along with increased volumes to process the need for fast, constant and correct standardisation methods, independent of seasonable fluctuations of the raw milk fat content, has increased. Control valves, flow and density meters and a computerized control loop are used to adjust the fat content of milk and cream to desired values. The pressure in the skim milk outlet must be kept constant in order to enable accurate standardisation. This pressure must be maintained regardless of variations in flow or pressure drop caused by the equipment after separation, and this is done with a constant-pressure valve located close to the skimmilk outlet. For precision in the process it is necessary to measure variable parameters such as:
• Fluctuations in the fat content of the incoming milk,
• Fluctuations in throughput,
• Fluctuations in preheating temperature.

Most of the variables are interdependent; any deviation in one stage of the process often results in deviations in all stages. The cream fat content can be regulated to any value within the performance range of the separator, with a standard deviation based on repeatability between 0.2 – 0.3% fat. For standardised milk the standard deviation based on repeatability should be less than 0.03%. Most commonly the whole milk is heated to 55 – 65°C in the pasteurizer before being separated. Following separation the cream is standardised at preset fat content and subsequently, the calculated amount of cream intended for standardisation of milk (market milk, cheese milk, etc.) is routed and remixed with an adequate amount of skimmilk. The surplus cream is directed to the cream pasteuriser. Under certain circumstances it is also possible to apply an in-line standardization system to a cold milk centrifugal separator. However, it is then very important that all fat fractions of the milk fat are given enough time at the low temperature (10 – 12 hours) for complete crystallisation.

The Bactofuge®

Bactofugation is a process in which a specially designed centrifuge called a Bactofuge is used to separate micro-organisms from milk. Originally the Bactofuge was developed to improve the keeping quality of market milk. At the present time bactofugation is also used to improve the bacteriological quality of milk intended for other products like cheese, milk powder and whey for baby food. Bacteria, especially heat resistant spores, have a significantly higher density than the milk. A Bactofuge is therefore a particularly efficient means of ridding milk of bacteria spores. Since these spores are also resistant to heat treatment, the Bactofuge makes a useful complement to thermisation, pasteurisation and sterilisation.
Decanter centrifuges

Centrifuges are used in the dairy industry to harvest special products like precipitated casein and crystallised lactose. Homogenisation has become a standard industrial process, universally practised as a means of stabilising the fat emulsion against gravity separation. Gaulin, who invented the process in 1899, described it in French as “fixer la composition des liquides”.

Effect of homogenisation

The effect of homogenisation on the physical structure of milk has many advantages:

• Smaller fat globules leading to no cream-line formation,
• Whiter and more appetizing colour,
• Reduced sensitivity to fat oxidation,
• More full-bodied flavor, better mouth feels,
• Better stability of cultured milk products.

However, homogenisation also has certain disadvantages:

• Homogenised milk cannot be efficiently separated.
• Somewhat increased sensitivity to light – sunlight and fluorescent tubes – can result in “Sunlight flavour”
• Reduced heat stability, especially in case of single-stage homogenisation, high fat content and other factors contributing to fat clumping.
• The milk will not be suitable for production of semi-hard or hard cheeses because the coagulum will be too soft and difficult to dewater.

Membrane technology

In the dairy industry, membrane technology is principally associated with

• Reverse Osmosis (RO) – concentration of solutions by removal of water
• Nanofiltration (NF) – concentration of organic components by removal of part of monovalent ions like sodium and chlorine (partial demineralisation)
• Ultrafiltration (UF) – concentration of large and macro molecules
• Microfiltration (MF) – removal of bacteria, separation of macro molecules

Evaporation

In the dairy industry evaporation is used for concentration duties such as milk, skim milk and whey. It is also used as a preliminary step to drying. Milk products intended for milk powder are normally concentrated from an initial solids content of 9 – 13% to a final concentration of 40 – 50% total solids before the product is pumped to the dryer. Evaporation in the dairy industry is boiling off water from the solution. To do this heat must be supplied. The products to be evaporated are normally heat sensitive and can be destroyed by adding heat. To reduce this heat impact, evaporation takes place under vacuum, sometimes at temperatures as low as 40°C. At the same time the evaporator should be designed for the shortest possible residence time. Most products can be concentrated with good results provided that the evaporator is designed for low temperature and short holding time.

Prerequisites for dairy processing

A number of service installations must be supplied for dairy operations. Among these are water, heat in the form of steam and hot water, refrigeration, compressed air and electricity. In the dairy raw milk passes through several stages of treatment in various types of processing equipment before reaching the consumer in the form of a finished, refined product. Production usually takes place continuously in a closed process, where the main components are connected by a system of pipes. The type of treatment involved and the design of the process depend on the end product. The process described in this chapter is general milk pasteurisation. This process is the basic operation in market milk processing, and also constitutes an important pretreatment stage in a chain of dairy processes such as cheese making and cultured milk production. The aim is to present some of Pasteurised milk products
Pasteurised milk products are liquid products made from milk and cream intended to be used directly by consumers. This group of products includes whole milk, skim milk, standardised milk, and various types of cream. De-aeration is practiced in certain cases when the milk has a high air content, and also when highly volatile off-flavour substances are present in the product. This may occur for example if cattle feed contains plants of the onion family. Processing of market milk products requires first-class raw material and correctly designed process lines if end products of highest quality are to be attained. Gentle handling must be ensured so that the valuable constituents are not adversely affected. Depending on legislation and regulations, the design of process lines for pasteurised market milk varies a great deal from country to country and even from dairy to dairy. For instance, fat standardisation (if applied) may be pre-standardisation, post-standardisation or direct standardisation. Homogenisation may be total or partial, etc. The “simplest” process is just to pasteurise the whole milk. Here the process line consists of a pasteuriser, a buffer tank and a filling machine. The process becomes more complicated if it has to produce several types of market milk products, i.e. whole milk, skim milk and standardised milk of various fat contents as well as cream of various fat contents.

Production of cream

Cream for sale to consumers is produced with different fat contents. Cream of lower fat content, 10 – 18%, is often referred to as half cream or coffee cream; it is increasingly used for desserts and in cooking. Cream with a higher fat content, typically 35 – 40 %, is usually considerably thicker. It can be whipped into a thick froth and is therefore referred to as “whipping cream”. Whipping cream is used whipped or unwhipped as a dessert, for cooking, etc.

Whipping cream

In addition to tasting good and keeping well, whipping cream must also have good “whippability”, i.e. it must be easy to whip and produce a fine cream froth with a good

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increase in volume (overrun). The froth must be firm and stable, and must not be susceptible to syneresis. Good whippability depends on the cream having a sufficiently high fat content. Whipping cream with 40% fat is usually easy to whip, but the whippability decreases as the fat content drops to 30% and below. However, it is possible to produce good whipping cream with a low fat content (about 25%) by adding substances which improve whippability, e.g. powder with a high lecithin content made from sweet buttermilk.

Half and coffee cream

Cream containing 10 – 18 % fat is characterised as half or coffee cream. Untreated milk from the storage tanks is heated re-generatively in the heat exchanger to separation temperature, 62 – 64°C. The milk then flows to the separator for separation to skim milk and cream with the required fat content, usually 35 – 40%. The treatment of the cream is the same as described for whipping cream, with the exception that the half cream is mixed with skim milk to obtain the required fat content. The cream is homogenised.

Two principal requirements must be met in production of cream:

• The cream should be viscous, to convey a more appetizing impression.

• The cream should have good coffee stability. It must not flocculate when poured into hot coffee

Long life milk

Sterilising a product means exposing it to such powerful heat treatment that all micro-organisms and heat-resistant enzymes are inactivated. Sterilised products have excellent keeping qualities and can be stored for long periods of time at ambient temperatures. Many dairies can therefore distribute sterilised products over long distances and thereby find new markets. With a product that can be stored for long periods without spoiling and with no need for refrigeration, there are many advantages for both the producer, the retailer and the consumer. The producer can for example reach geographically wider markets, simplify deliveries, use fewer and cheaper distribution vehicles and eliminate return of unsold
products. Handling is simplified for the retailer, as expensive refrigerated display space can be eliminated and stock planning is simplified. Finally, the consumer gains in convenience as he can make fewer trips to the shops, there will be less congestion in the home refrigerator and he will have emergency reserves available for unexpected guests. This includes expensive products such as cream, desserts and sauces.

Production of long life milk

Two methods are used for the production of long life milk:

A In-container sterilisation, with the product and package (container) being heated at about 116°C for about 20 minutes. Ambient storage.

B Ultra High Temperature (UHT) treatment with the product heated at 135–150°C for 4–15 seconds followed by aseptic packaging in packages protecting the product against light and atmospheric oxygen.

Cultures and starter manufacture

Bacteria cultures, known as starters, are used in the manufacture of yoghurt, kefir and other cultured milk products as well as in butter making and cheese making. The starter is added to the product and allowed to grow there under controlled conditions. In the course of the resulting fermentation, the bacteria produce substances which give the cultured product its characteristic properties such as acidity (pH), flavor, aroma and consistency. The drop in pH, which takes place when the bacteria ferment lactose to lactic acid, has a preservative effect on the product, while at the same time the nutritional value and digestibility are improved.

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. 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
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, di-acetyl, acetaldehyde and several other substances are formed in the conversion process, and these give the products their characteristic fresh taste and aroma. The micro-organisms used in the production of kefir and koumiss also produce ethyl alcohol. 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

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%

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, flavor 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 flavor and aroma of yoghurt differ from those of other acidified products, and the volatile aromatic substances include small quantities of acetic acid and acetaldehyde.

Yoghurt is typically classified as follows:

- Set type incubated and cooled in the package,
- Stirred type incubated in tanks and cooled before packing,
- Drinking type similar to stirred type, but the coagulum is “broken down” to a liquid before being packed,
- Frozen type incubated in tanks and frozen like ice cream,
- Concentrated incubated in tanks, concentrated and cooled before being packed. This type is sometimes called strained yoghurt.

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 “tin 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.

Drinking yoghurt

A low-viscosity drinkable yoghurt, normally with a low fat content, is popular in many countries. 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. 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.

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.
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. The only difference is the type of cultures used. Concentrated yoghurt is known under names such as "strained" type yoghurt and Labneh.

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.

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, like other cultured products, has a limited shelf life. Strict hygiene is important to product quality.

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-flavors and short shelf life. The raw material can be sweet buttermilk from the manufacture of butter based on sweet cream, skim milk 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 skim milk or low fat milk, grains of butter are also added to the product to make it look more like buttermilk.

Butter and dairy spreads

The International Dairy Federation, IDF, has introduced a standard concerning butters and spreads, viz. IDF Standard 166:1993, “Guidelines for Fat Spreads”. These guidelines are intended to provide a broad framework permitting the development of more specific group or individual standards according to the requirements of individual countries.

Butter

Butter is usually divided into two main categories:

• sweet cream butter;

• cultured or sour cream butter made from bacteriologically soured cream.

Butter can also be classified according to salt content: unsalted, salted and extra salted. Today’s commercial butter making is a product of knowledge and experience gained over the years about such matters as hygiene, bacterial acidification and temperature treatment, as well as the rapid technical development that has resulted in the advanced machines now used. The colour of butter varies with the content of carotenoids, which make up from 11 to 50% of the total vitamin A activity of milk. As the carotenoid content of milk normally fluctuates between winter and summer, butter produced in the winter period has a brighter colour. (In this context it might be mentioned that butter made of cream from buffalo milk is white, as buffalo milk does not contain carotenoids.) Butter should also be dense and
taste fresh. The water content should be dispersed in fine droplets so that the butter looks dry. The consistency should be smooth, so that the butter is easy to spread and melts readily in the mouth. Sour cream butter should smell of diacetyl, while sweet butter should taste of cream – a faint “cooked” flavour is acceptable in the case of sweet butter.

Butter made from sour cream has certain advantages over the sweet cream variety. The aroma is richer, the butter yield higher, and there is less risk of re-infection after temperature treatment as the bacteria culture suppresses undesirable micro-organisms.

Anhydrous Milk Fat (AMF) (Butter oil)

Anhydrous milk fat and butter oil are products consisting of more or less pure milk fat. Although they are modern industrial products, they have ancient traditional roots in some cultures. Ghee, a milk fat product with more protein and a more pronounced flavour than AMF, has been known in India and Arab countries for centuries. Anhydrous milk fat products are manufactured in three distinct qualities specified by FIL-IDF International Standard 68A:1977:

- Anhydrous Milk Fat must contain at least 99.8 % milk fat and be made from fresh cream or butter. No additives are allowed, e. g. for neutralization of free fatty acids.
- Anhydrous Butter oil must contain at least 99.8 % milk fat but can be made from cream or butter of different ages. Use of alkali to neutralise free fatty acids is permitted.
- Butter oil must contain 99.3 % milk fat. Raw material and processing specifications are the same as for Anhydrous Butter oil.

Cheese

- Cheese has been made in most cultures from ancient times.
- Cheese is a milk concentrate, the basic solids of which consist mainly of protein, actually casein, and fat. The residual liquid is called whey.
- As a rule of thumb, the casein and fat in the milk are concentrated approx. 10 times in production of hard and some semi-hard types of cheese.
The moisture content of the cheese serves to distinguish various categories, such as hard (low-moisture), semi-hard and soft cheeses.

A generally accepted classification of cheese is given in FAO/WHO Standard No. A 6.

Each category is distinguished by a number of characteristics, such as structure (texture, body), flavour and appearance, which result from the choice of bacteria and technique employed.

Processed cheese is a heat-treated product based on different types of cheese of varying age according to FAO/WHO Standards No. A 8 (b).

Whey cheese is a type of cheese predominantly produced in Norway and Sweden and is defined according to FAO/WHO Standard No. A 7 as follows:

Whey cheeses are products obtained by the concentration of whey and the moulding of concentrated whey, with or without the addition of milk and milk fat.

Cream cheese is a soft unripened cheese briefly described in the FAO/WHO Standard C 31 as possessing a mild creamy or acid flavour and aroma typical of a milk product cultured with lactic acid and aroma producing bacteria. It spreads and mixes readily with other foods.

Hard types of cheese

Processing line for Emmenthal cheese

Milk intended for Emmenthal cheese is normally not pasteurised, but the fat content is standardised.

Processing line for Cheddar cheese

Cheddar cheese and similar types are the most widely produced in the world. Cheddar cheese generally has a moisture on fat-free basis (MFFB) of 55%, which means it can be classified as hard cheese although it is on the verge of semi-hard types.

Semi-hard types of cheese

Processing line for Gouda cheese

Gouda is probably the best-known representative of typical round-eyed cheeses.
Processing line for Tilsiter cheese

Tilsiter has been chosen as a representative of granular textured cheese.

Processing line for Mozzarella cheese

The typical Mozzarella cheese is originally and still based on buffalo milk deriving from the buffalos bred in central Italy. Mozzarella is also produced from a mixture of buffalo and cow milk, but nowadays most commonly from cow milk alone. Mozzarella is also called pizza cheese in some countries.

Semi-hard, semi-soft and soft types of cheese

Sometimes it is difficult to classify a type of cheese as distinctly semi-hard or semi-soft, and as semi-soft or soft, as some types occur in intermediate forms. The Tilsiter types are typical representatives of the former intermediate forms, as are also Blue or Blue-veined types of cheese, while Brie types may represent the latter. The following brief descriptions refer to methods of production of:

- Blue (veined) cheese, representative of semi-hard and semi-soft types of cheese with inside mould formation by Penicillium roqueforti.
- Camembert cheese, representative of semi-soft/soft types of cheese with outside surface mould formation by Pencillium camemberti and Penicillium candidum.
- Cottage cheese and Quarg as representatives of soft fresh cheese.

Quarg

Quarg is defined as “a sour skim milk curd cheese usually consumed unripened”. Quarg is often mixed with cream, and sometimes also with fruit and seasonings. The standard of the product varies in different countries and the dry matter in non-fat Quarg may vary between 14 and 24%.

Whey processing

Whey, the liquid residue of cheese and casein production, is one of the biggest reservoirs of food protein still remaining largely outside human consumption channels.
World whey output, at approximately 120 million tonnes in 1990, contains some 0.7 million tonnes of relatively high-value protein, equal to the protein contents of almost 2 million tonnes of soya beans. Yet, despite the chronic protein shortage in large parts of the world, a very considerable proportion of the total whey output is still wasted - the proportion of wastage was roughly 50% in 1989-1990. Whey comprises 80-90% of the total volume of milk entering the process and contains about 50% of the nutrients in the original milk: soluble protein, lactose, vitamins and minerals. Whey as a by-product from the manufacture of hard, semi-hard or soft cheese and rennet casein is known as sweet whey and has a pH of 5.9 – 6.6.

Condensed milk

The method of preserving milk by sterilising evaporated milk in sealed containers was developed at the beginning of the 1880s. Earlier, in about 1850, the method of preserving evaporated milk by the addition of sugar had been perfected by an American. The manufacture of condensed milk, using these two methods, has developed into a large-scale industry. A distinction is made between two different types; unsweetened (evaporated) and sweetened condensed milk.

Unsweetened condensed milk (also called double concentrated milk) is a sterilised product, light in colour and with the appearance of cream. The product has a large market, for example in tropical countries, at sea and for the armed forces. It is used where fresh milk is not available. Unsweetened condensed milk is also used as a substitute for breast milk. In this case vitamin D is added. It is also used for cooking, as coffee cream, etc. The product is made from whole milk, skim milk or recombined milk with skim milk powder, anhydrous milk fat (AMF) and water as typical ingredients.

The evaporated product, the unsweetened condensed milk, is normally packed in cans which are then sterilised in autoclaves or horizontal sterilisers. Concentrates based on recombined milk can be either canned and sterilised in the cans or UHT-treated and packed in paperboard packages. Sweetened condensed milk is basically concentrated milk to which sugar has been
added. The product is yellowish in colour and looks like mayonnaise. The high sugar concentration in sweetened condensed milk increases the osmotic pressure to such a level that most of the microorganisms are destroyed. The sugar concentration in the water phase must not be less than 62.5% or more than 64.5%. At the latter level the sugar solution reaches its saturation point and some sugar will then crystallise, forming a sediment. Sweetened condensed milk can be made from whole milk or skim milk, or from recombined milk based on skim milk powder, anhydrous milk fat (AMF) and water.

Milk powder

The method of preserving various foodstuffs by drying them, and thereby depriving micro-organisms of the water necessary for their growth, has been known for centuries. According to Marco Polo's accounts of his travels in Asia, Mongolians produced milk powder by drying milk in the sun. Today milk powder is produced on a large scale in modern plants. Skim milk powder has a maximum shelf life of about 3 years. Whole milk powder has a maximum shelf life of about 6 months. This is because the fat in the powder oxidises during storage, with a consequent gradual deterioration in taste.

Various uses of milk powder

Dried milk is used for many applications, such as:

• recombination of milk
• mixing into dough in the bakery industry to increase the volume of the bread and improve its water-binding capacity. The bread will then remain fresh for a longer period of time.
• mixing into pastry dough to make it crisper
• as a substitute for eggs in bread and pastries
• producing milk chocolate in the chocolate industry
• producing sausages and various types of ready-cooked meals in the food industry and catering trade
• as a substitute for mother's milk in baby foods
• production of ice-cream
• animal feed

Skim milk powder

Skim milk powder is by far the most common type of milk powder. Each field of application makes its own specific demands on milk powder. If the powder is to be mixed with water in recombined milk for consumption, it must be easily soluble and have the correct taste and nutritive value.

Whole milk powder

Spray dried whole milk powder is normally produced from fat standardized milk. After standardisation the milk need not be homogenised provided that it is thoroughly agitated, without air inclusion, before evaporation and again between evaporation and spray drying. The concentrate is however homogenized in certain cases for production of instant whole milk.

Instant-milk powder

Special methods for the production of both skim milk and whole milk powder with extremely good solubility – known as instant powder – are also available. This powder has a larger grain size, influenced by agglomeration, than normal spray powder and dissolves instantly even in cold water.

Recombined milk products

Milk is a perishable commodity, and therefore scarce in many countries with little or no dairy production of their own. Fresh milk has a very limited shelf life and is easily spoiled by bacteria enzymes and exposure to direct sunlight. Distribution is especially difficult in tropical climates and in regions where the distance between producer and consumer is great. In such places fresh milk is replaced by more durable forms of milk, such as condensed or UHT-sterilised milk. Recombination is an alternative method of supplying a product that closely resembles fresh dairy milk to markets where the genuine article is not available. The
manufacture of recombined milk and milk products has been well established in many countries around the world, and a variety of processes and equipment has been developed for this purpose. The principles of the processes are much the same. The initial applications were fluid milk, but this was followed by production of recombined evaporated milk and sweetened condensed milk. Today recombination also includes yoghurt, butter and cheese. The processes have been developed over the years from simple batch operations to sophisticated systems with high capacities. The main processes in the basic reconstitution and recombining operations are:

- Raw material handling
- Weighing and mixing
- Filtration, homogenisation and pasteurization

Definitions important to be known in a dairy industry:

The following definitions are given as a guide to clarify certain expressions used in the industry.

*Reconstituted milk* is the liquid milk obtained by adding water to skimmilk powder (SMP) or whole milk powder (WMP).

*Recombined milk* is the liquid milk obtained by adding water to SMP and adding milk fat separately in such a quantity that the desired fat content is achieved.

*Reconstituted milk products* are the products resulting from addition of water to the dried or condensed form of product in the amounts necessary to re-establish the specified water/solids ratio.

*Recombined milk products* are manufactured by mixing milk fat and milk solids-non-fat (MSNF), with or without water. This combination must be made so as to re-establish the specified fat to MSNF ratio and dry matter (DM) to water ratio.
*Recombined, modified milk and milk products* are products made from dairy-product ingredients with compositions other than normal dairy products, e.g. flavoured products, butter from fractionated fat, or dietary evaporated or condensed milk.

*Filled milks and milk products* are "semi-dairy" products in which the milk fat is replaced by vegetable oils, e.g. liquid milk, evaporated milk, condensed milk or cheese. Alternative terms could be "imitation" or "substitute".

*Fortified milk* is made from fresh milk, reconstituted milk or recombined milk with the addition of one or more ingredients of dairy products.

*Toned milk* is fresh milk mixed with reconstituted or recombined skim milk in order to prepare normal composition milk or modified milk from high-fat milk by adjusting the MSNF.

*Anhydrous milk fat (AMF)* is a pure fat product obtained from fresh milk, cream or butter to which no neutralizing substances have been added.

*Anhydrous butter oil* is an all-fat product made from cream or butter of unspecified age.

Butter oil is a product made from cream or butter of unspecified age which may have a lower fat content.

*Vegetable oils* are refined, bleached, de-odourised oils, preferably coconut, palm and soybean oils.

**Ice cream**

It is uncertain how long ice cream has been produced, but it probably originates from China. From very old writings it has been learned that the Chinese liked a frozen product made by mixing fruit juices with snow, what we now call water ice. This technique later spread to ancient Greece and Rome, where the wealthy, in particular, were partial to frozen desserts. After disappearing for several centuries, ice creams in various forms reappeared in Italy in the Middle Ages, most probably as a result of Marco Polo returning to Italy in 1295 after a 16–17 year stay in China, where he had learned to appreciate a frozen dessert based on milk. From Italy ice cream spread over Europe during the seventeenth century, and long
remained a luxury product for the royal courts. Sales of ice cream to the general public in the United States started in the eighteenth century, but did not become widespread until the nineteenth century, when the first wholesale firm appeared on the market. Categories of ice cream

Ice cream can be divided into four main categories according to the ingredients used:

• Ice cream made exclusively from milk products,
• Ice cream containing vegetable fat,
• Sherbet ice cream made of fruit juice with added milk fat and milk solids-non-fat,
• Water ice made of water, sugar and fruit concentrate.

The first two types of ice cream account for an estimated 80 – 90% of the total world production. The following description is therefore confined to these two types.

Packing in cups, cones and containers

Ice cream is packed in cups, cones and containers (1 to 6 litres) in a rotary or in-line filling machine. These can be filled with various flavors, and the products may be decorated with nuts, fruits and chocolate. The packs are lidded before leaving the machine, after which they are passed through a hardening tunnel where final freezing down to −20°C takes place. Before or after hardening the products can be manually or automatically packed in cartons or bundled. Plastic tubs or cardboard cartons can be filled manually from a can equipped to supply single or twin flavors.

Extrusion of sticks and stick less products

Extruded ice cream products are normally produced on a tray tunnel extruder. The ice cream can be extruded directly onto trays in a variety of different shapes and sizes, or into a cup or cone, or on to a sandwich wafer. Decoration can be applied, after which the products are carried on the trays through a hardening tunnel where they are frozen to −20°C. After hardening the products are removed from the trays ready for wrapping and packing in
cartons, either manually or automatically. Such a system is continuous; depending on the
capacity of the extruder and the type of product, 5–25 000 units can be produced per hour.

Moulding of bars

Ice cream or water ice bars are made in special machines, also called stick novelty
freezers, with pockets in which the ice cream or water ice is moulded. Ice cream is supplied
direct from the continuous freezer at a temperature of approx. –3°C. The filled moulds are
conveyed stepwise through a brine solution having a temperature of –40°C, which freezes
the ice cream or water ice solution. Sticks are inserted before the moulds are completely
frozen.

The frozen products are removed from the moulds by passing them through a warm
brine solution which melts the surfaces of the products and enables them to be removed
automatically by an extractor unit. After extraction the bars (novelties) may be dipped in
chocolate before being transferred to the wrapping machine. Since the products are fully
frozen, they can be taken straight to the cold store after wrapping and cartoning. A variety of
different shaped products can be produced in stick novelty freezers as well as products with
one, two or three flavours and shell-and-core products with a core of ice cream and a shell of
water ice.

Casein

Casein is the major protein in cow’s milk and constitutes about 80% of the total
protein content of which the rest, some 20%, are the whey or serum proteins. Casein is the
basic component of ordinary cheese. In the cheese making process, casein is precipitated by
the action of rennet enzyme, and a coagulum is formed consisting of casein, whey proteins,
fat, lactose and the minerals of the milk. Commercial casein is made from skim milk by one
of two general methods –precipitation by acid or coagulation by rennet. As much of the fat,
whey proteins, lactose and minerals as possible must be removed by multistage washing in
water, as they reduce the quality of the casein as well as its keeping quality. Dried, properly
produced casein has a relatively good keeping quality and is used mainly in the food and chemical industries.

Types of casein

Casein is usually divided into the following types:

- rennet casein, obtained by enzymatic precipitation;
- acid casein, obtained by acidifying skimmilk to the isoelectric point (pH 4.6 – 4.7).

In addition to these two main types there are other commercially available casein products of importance, viz.:

- co-precipitate, made by heating skimmilk to a high temperature and then precipitating the casein/whey protein complex, usually with calcium chloride. The co-precipitate also contains whey proteins and calcium.
- caseinates, commonly sodium caseinate, obtained from acid casein dissolved in sodium hydroxide.

Cleaning of dairy equipment

Aspects of cleaning

The arrangements for cleaning equipment that comes in contact with products are an essential part of a food processing plant. It must be kept in mind that food manufacturers are always obliged to maintain high hygienic standards; this applies both to the equipment and, naturally, to the staff involved in production. This obligation can be considered under three headings:

1. Trade obligation
2. Moral obligation
3. Legal obligation

Trade obligations

Good, wholesome, clean products that keep well and are free from health hazards are obviously good for trade; customers will buy the same product again. If however a product is
contaminated, does not keep well or is the subject of complaints to the authorities, the reverse is true, and the resulting publicity is very damaging. The potential effects of poor cleaning, poor standards and poor quality must be kept in mind at all times.

Moral obligation

Most of the customers who consume the products never see the factory or how the products are handled. They trust the company, rely on its reputation, and take it for granted that operations are carried out under the cleanest of conditions by well-trained staff who are continually aware and conscious of these factors.

Legal obligation

The law attempts to protect the customer and purchaser in respect of health and quality. Failure to meet legal obligations, national or local, can result in very severe action. Prosecution proceedings can be very damaging. Prevention is better than cure, and companies are obliged to meet legal requirements and maintain high standards. Milk and milk products by their nature are ideal media for the growth of micro-organisms, including many pathogens. As a result of this there is more legislation concerning milk – its production, handling, processing, packaging, storage and distribution – than any other food product. Each country has its own national and perhaps local legislation standards.

Cleaning procedures

Cleaning of dairy equipment was formerly done (and still is in some places) by people armed with brushes and detergent solutions, who had to dismantle equipment and enter tanks to get at the surfaces. This was not only laborious but also ineffective; products were often re-infected from imperfectly cleaned equipment. Circulatory cleaning-in-place (CIP) systems adapted to the various parts of a processing plant have been developed to achieve good cleaning and sanitation results.

Cleaning operations must be performed strictly according to a carefully worked out procedure in order to attain the required degree of cleanliness. This means that the sequence
must be exactly the same every time. The cleaning cycle in a dairy comprises the following stages:

- Recovery of product residues by scraping, drainage and expulsion with water or compressed air;
- Pre-rinsing with water to remove loose dirt;
- Cleaning with detergent;
- Rinsing with clean water;
- Disinfection by heating or with chemical agents (optional); if this step is included, the cycle ends with a final rinse, if the water quality is good.

Verifying the cleaning effect

Verification of the effect of cleaning must be regarded as an essential part of cleaning operations. It can take two forms: visual and bacteriological inspection. Beseldom accessible for visual inspection. This must be replaced by bacteriological monitoring, concentrated to a number of strategic points in the line. CIP results are usually checked by cultivating coliform bacteria. When a swab test of a surface is made, the criterion is less than one coli bacterium per 100 cm2 of the checked surface. The result is unacceptable if the count is higher. These tests can be made on the surfaces of the equipment after completion of the CIP program. This applies to tanks and pipe systems, especially when excessively high bacteria counts have been detected in the products. Samples are often taken from the final rinse water or from the first product that passes through the line after cleaning. All products must be checked for bacteriological quality in their packages to obtain full quality control of the manufacturing process. The complete quality control program, in addition to the coliform test, also includes determination of the total count of micro-organisms and organoleptic control (tasting).

Dairy effluents

Water used in domestic and industrial applications become polluted to a greater or lesser extent. Water is also used as a transport medium to carry away waste products. As
awareness of the importance of improved standards of water treatment grows, process requirements become increasingly exacting. The food industry contributes to a great extent to pollution, particularly as the pollutants are of organic origin. Organic pollutants normally consist of 1/3 dissolved, 1/3 colloidal and 1/3 suspended substances, while inorganic materials are usually present mainly in solution.

Dairy waste water

Dairy waste water can be divided into three categories:

1 Cooling water
2 Sanitary waste water
3 Industrial waste water

The following general recommendations can serve as a guide to reducing wastage of water and product:

General milk treatment

• In reception of milk, particularly when tankers are emptied, it is important that the outlet from the tankers is at least 0.5 m above the receiving container or tank, and that the connecting hose is well streched, toensure that the tankers are completely drained.

• All pipelines must be identified and marked to avoid wrong connections that would result in unwanted mixing of products as well as leakage of milk.

• When pipes are installed they should be laid with a slight and correctly calculated gradient to make them self-draining. In addition, the pipes must be well suppported to prevent vibration, which could cause the couplings to work loose and thus cause leakage.

• All tanks should be equipped with level controls to prevent overflow. When the highest permitted level is reached, either the feeding pump is automatically stopped and the plant operator alarmed, or an automatic valve system is activated to route the product to another preselected tank.
• It is better to prevent wastage of product in the first place than to flush it away with a hose afterwards. Try to keep the floors dry; this also makes leaks easier to detect.

• Make sure that the piping system and tanks are properly emptied before they are rinsed out with water. Check that couplings are airtight; if air leaks into the piping system it will cause increased burning-on in heaters, erosion problems in homogenisers and foaming in milk and cream tanks (which will then be harder to empty completely).