SCHOOL OF CHEMICAL AND BIO-ENGINEERING
ADDIS ABABA INSTITUTE OF TECHNOLOGY
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Dairy Products Processing Technology

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Course content…

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(Fluid milk products)

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Course content ...Cont'd

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Milk as a Raw Material and Food

- **Milk** is a unique, nutritious and a major source of energy and many other essential nutrients (Oldest food and the most important)
- Throughout the world, **milk** and **milk products** are indispensable components of the food chain.
- **Raw milk:** The lacteal secretion , practically free from **colostrum**, obtained by the complete milking of one or more **healthy cows**.
- **Nutrient dense food** with a long history of contributing to health
- Not only do individual consumers use liquid milk for beverages and cooking, but food manufacturers use vast quantities of milk powder, concentrated milks, butter, and cream as raw materials for further processing.

Consumer Milk Products

- Homogenized milk: ≥3.25% fat
- Reduced fat milk: 2% fat
- Low fat milk: 1% fat
- Fat-free milk: skim milk, <0.5% fat (all with 8.25% solids-non-fat)

Other “milk products”

- Lactose reduced milks, heavy cream, cultured milks, yogurt, cottage cheese (Various), Ice-cream, Powder milk, Evaporated and Condensed milk, Milk imitations'.
- Imported dairy products: Sterilized
- All theses depends on National or Regional Compulsory Standards of Dairy Products.
- Dairy processing experts must be involved in standard development to provide consultation on critical issues
- Ethiopian Dairy Board: Shared Responsibility
- Coming soon if there is a positive development scenario

Pasteurized Milk Ordinance

- Produced by Public Health Service/Food and Drug Administration
- Sanitary regulations for milk and milk products
- **Specifies sanitation measures throughout production, handling, pasteurization, and distribution of milk**
- Good manufacturing practices

Milk and Milk products

- **Milk is a marvel of nature & a very variable Biological Fluid: Healthy Food**
- **The importance of milk and milk products in the diet**
- **Intake of milk and milk products throughout life**
- **Dairy food intake improves nutrient intake**
- **Sources of milk-Species:**

Table 1. Average composition (%) of milk of some species of mammal

Species	Total solids	Fat	Protein	Lactose	Ash
Human	**12.2**	**3.8**	**1.2**	**7.0**	**0.2**
Cow	**12.6**	**3.7**	**3.4**	**4.8**	**0.7**
Goat	**12.3**	**4.5**	**2.9**	**4.1**	**0.8**
Ewe	19.3	7.4	5.5	5.4 1.0	
Pig	18.8	6.8	4.8	6.2	1.0
Mare	11.2	1.9	2.5	6.3	0.5
Ass	11.3	1.4	2.0	7.4	0.5
Reindeer	33.1	16.9	11.5	4.7	-
Domestic rabbit	32.8	18.3	10.9	1.8	1.8
Bison	14.6	3.5	4.5	6.0	0.6
Indian elephant	31.3	17.6	9.9	3.1	0.7
Polar bear	47.7	33.1	10.9	3.3	1.4
Grey seal	64.0	53.1	11.2	0.7	-
Camel	**12.9**	**4.2**	**3.7**	**4.1**	**0.9**

Function of Milk and Composition

- Growth and reproduction
- Supply of energy, Maintenance and repairs
- Appetite satisfaction
- **Average composition of milk (Comparison)**
- Fat (3.8 ;3.7 % for human and cow respectively): Triglyceride
- Protein (1.2;3.4):80% casein
- Milk sugar: Lactose (7.0;4.8)-Carbohydrate of milk
- Ash (0.2;0.7) and **Total milk solids** (12.2,12.6)
- Water (79.8; 87.4)- **Average composition of H_2O in milk ~ 87-88%**
- **Total milk solids-TMS** (Carbohydrates, fat, protein & minerals)
- **Milk solids** nonfat-**MSNF**

Factors Affecting Milk Composition

- Milk composition can be affected by a number of factors mainly
- **Genetic** and **Environmental** Factors
- **<u>Genetic factors</u>** (**Breed** and individuality of the cow)

- Both milk and composition vary considerably among breeds of dairy cattle

- Jersey and Guernsey breeds ~ 5-6% fat
- **Holstein-Friesian** and shorthorns ~3.5% fat
- **Zebu cows can give milk containing up to 7 % fat**

- **<u>Environmental factors</u>**

- **Interval between milking/time of milking (fat content , SNF)**
- **Stage of lactation (Fat, lactose & protein)**
- **Age and health (Fat content decreases with age)**
- **Feeding regime and Completeness of milking**
- **Seasonal variation**

Physical Properties of Milk

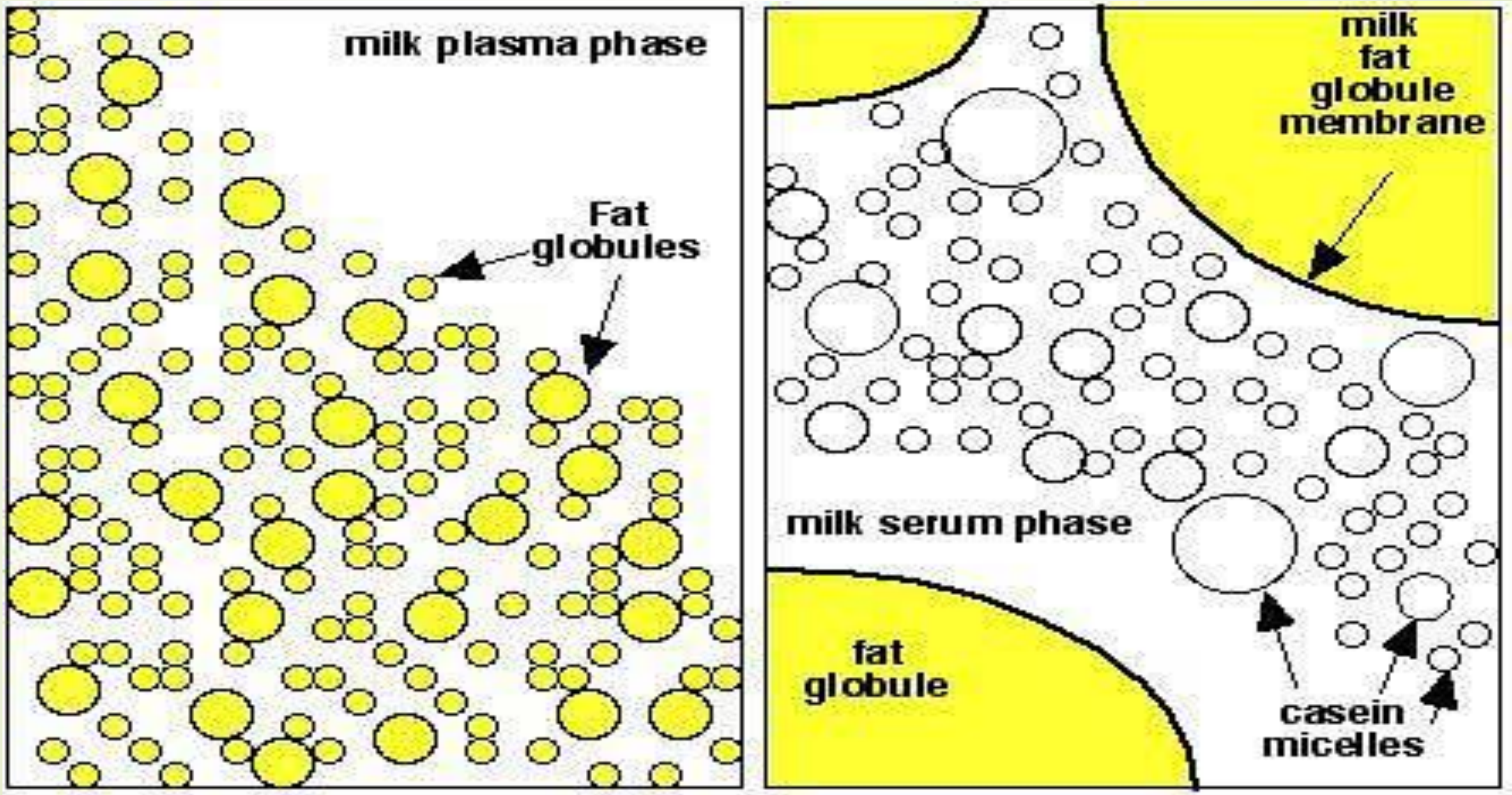
- **Physical status of milk**
- ✓ **Ionic solutions (0.01-1nm,Particle diameter)**
- ✓ **Molecular solutions (0.1-1nm)**
- ✓ **Dispersions**
- ✓ **Colloids (fine dispersion) (1-100**
- ✓ **Emulsions (coarse dispersion) 50-100nm**

Milk Composition
Physicochemical Properties

- Milk might seem to be a simple white liquid
- ✓ A complex mixture of a wide range of compounds. The gross properties of milk include:
- Milk is an **emulsion** of fat globules, and
- A **suspension** of casein micelles (casein, Ca, P)
- All of which are suspended in an aqueous phase, that contains solublized lactose, whey proteins, and some minerals
- **Leukocytes (somatic cells)** in milk are part of the suspended phase

In the diagram below, **milk** is viewed at two magnifications; the **left view** is what would be seen at about 500X magnification, and the **right view** at about

50,000X



Structure of milk

- The structure illustrates that milk is an emulsion of milk fat globules (**left view**).
- In the **right view**, the casein micelles are in a colloidal suspension in the serum phase of milk (the whey).
- **Milk fat** globules in cow milk range in size from **0.1 to 15 µm**
- **Milk fat** has a density of **about 0.92 g/ml**.
- Casein micelles range in size from about 10 to 300 nanometers and have a density of 1.11 g/ml.
- The number of casein molecules in a micelle ranges from 20,000 to 150,000. The calcium content in micelles is about 8 g/ 100 g casein

…Physical Properties

- Some other physicochemical characteristics of cow milk:
- **pH** of fresh milk has about 6.5 - 6.9 **-slightly acidic** (Human milk is about 7.0; cow milk which contain **colostrum/bacterial deterioration** $<$ 6.0; milk from cows with mastitis $>$ 7.5)
- **Milk is a buffer solution** (a material that resist change in pH on addition of acid or base- Consists of a weak acid or a weak base and its salt)
- **Osmolality** ~ 0.3 M (osmotic pressure ~ 700 kPa)
- **Ionic strength** ~ 0.08 molar
- **Water activity** (a_w **)** ~ 0.993 can be attacked by ?

Density

- The density (g/L) of milk is rather dependent with temperature
- $\rho_{milk} = 1.003073 - 0.000179t - 0.000368F + 0.00374SNF$

Where t = temperature in º C; F= % fat; SNF= in %

Sample problem

- **Question:**
- If you collected milk from a Zebu cow (6.0% milk fat; 17% milk solids) and stored the sample at 4 ^{o}C, how would the density of that milk compare with the density of milk from you collected from a Holstein-Friesian cow (3.4% milk fat; 14.2% solids) and stored at 4 ^{o}C?

-What is the density of milk if your milk samples were stored at room temperature (20 ^{o}C)?

Relation between Density and Specific Gravity

- **Specific gravity** of whole cow milk (ratio of density of milk to density of water)
- **Varies among breeds and among cows within breed**
- For example, mean specific gravity of **Holstein** milk at 20 °C/20 °C is 1.0330 (range 1.0268 to 1.0385)
- **Ayrshire** milk specific gravity is 1.0317 (range 1.0231 to 1.0357), while **Jersey** milk also has a mean of 1.0330 (range 1.0240 to 1.0369).

Viscosity of Milk

- **Viscosity** is measured in poise, defined as the force in dynes per square cm required to maintain a relative velocity of 1 cm/sec between two parallel planes 1 cm apart
- At 20 ^{o}C, whole milk is ~20 centipoise, skim milk ~ 1.5 centipoise, and whey ~ 1.2 centipoise
- **Milk with colostrums contains higher viscosity**

Freezing point of milk

- Freezing point of a solution depends on the number of particles in the solvent (water phase of milk), rather than the kind of particles.
- Water without solutes will freeze at zero degrees C. The presence of any solutes will depress freezing point below zero degrees C. The freezing point of milk depends upon the concentration of water-soluble components.
- The current official freezing point limit -0.505 ^{o}C

Milk color-
Why cow milk has whitish-yellow color ?....

- Refractive **index of milk** ~1.338 but water has ~1.330, because refractive index of the solution depend on the refractive index of the solvent and the particles in the solution.
- Casein micelles are the primary contributors to the higher refractive index of milk compared with water.
- **Light scattering by fat globules and casein micelles** are the primary contributors to the **color of milk.**
- Whey proteins are too small in size and leukocytes (somatic cells) are too low in concentration to contribute substantially to light scatter in milk.
- The carotene in fat globules scatters yellow light and is responsible for the yellow color of cream.

Milk Color

- ✓**Milk** appears **white** due to the **reflection of light** from colloidally dispersed casein protein and calcium phospahte particles in the milk dispersion
- ✓However, an **off-white color** may be due to **carotenoid pigment** in the animal feed.
- ✓A **bluish** color may be observed in milk skimmed of fat

Milk Chemical Properties

- **Milk constituents**

- The quantities of the main milk constituents can vary considerably depending on:

- The individual animal and its breed
- Stage of lactation, age and health status.
- Herd management practices and environmental conditions also influence milk composition.

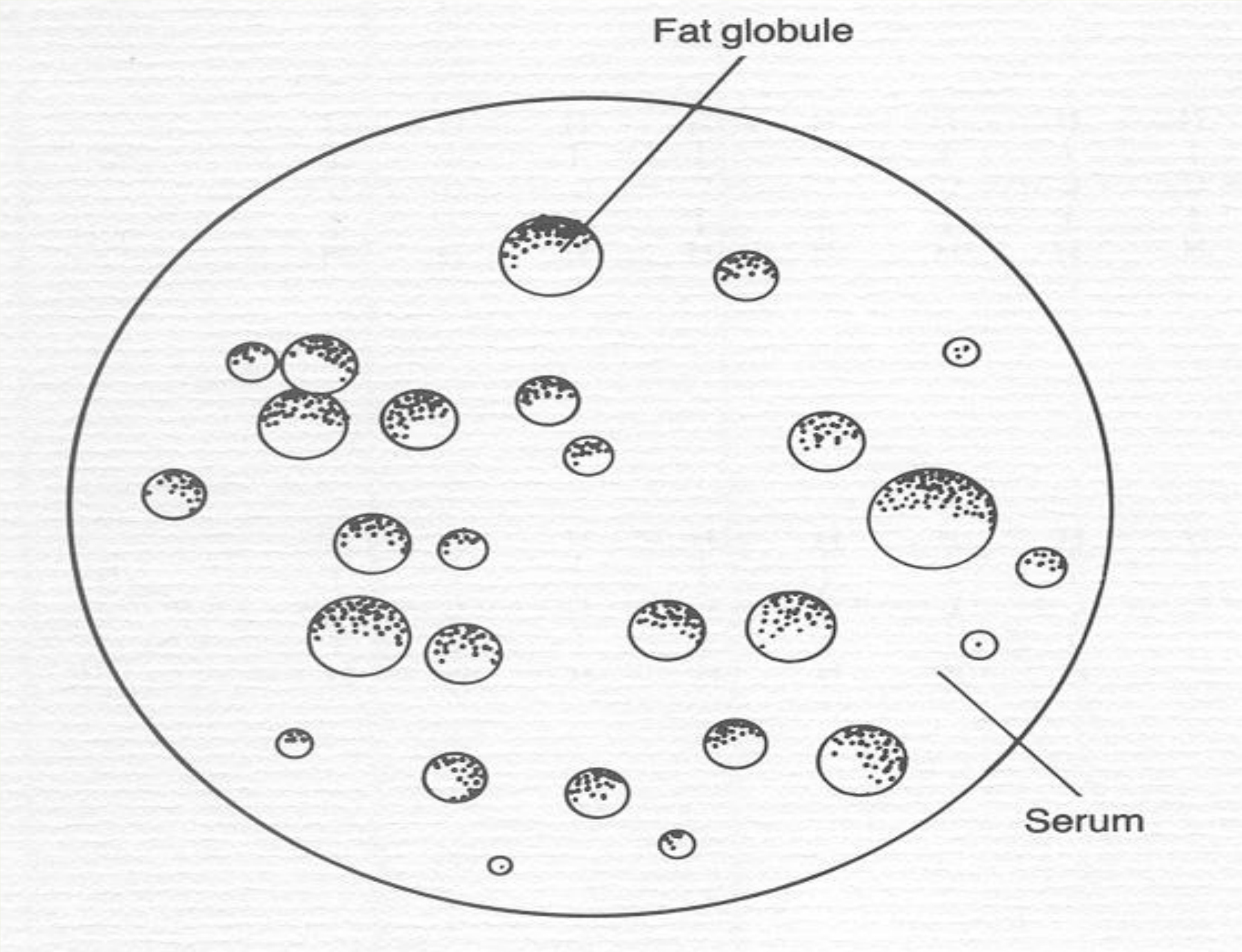
Average Composition of cow's milk

Main constituent	Range (%)	Mean (%)
Water	85.5 – 89.5	87.0
Total solids	10.5 – 14.5	13.0
Fat	2.5 – 6.0	4.0
Proteins	2.9 – 5.0	3.4
Lactose	3.6 – 5.5	4.8
Minerals	0.6 – 0.9	0.8

Milk composition

- ***Water*** is the main constituent of milk and much milk processing is designed to remove water from milk or reduce the moisture content of the product.
- **_Milk fat_: Under the microscope cream can be seen to consist of a large number of spheres of varying sizes floating in the milk.**
- **Each sphere is surrounded by a thin skin-the fat globule membrane-which acts as the emulsifying agent for the fat suspended in milk**
- **The membrane protects the fat from enzymes and prevents the globules coalescing into butter grains.**
- **The fat is present as an oil-in-water emulsion: this emulsion can be broken by mechanical action such as shaking.**

Fat globules in milk

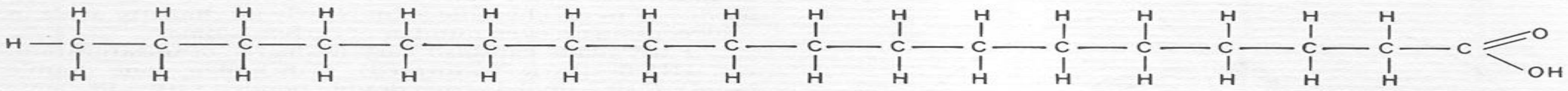


Milk fat

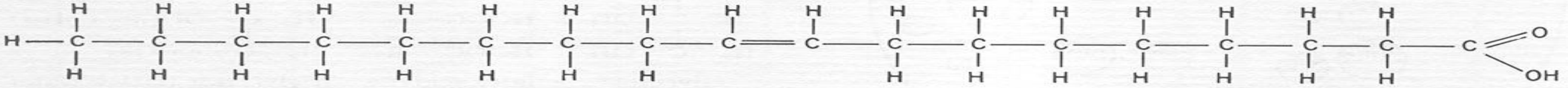
- **Fats** are partly solid at room temperature. The term oil is reserved for fats that are completely liquid at room temperature. Fats and oils are soluble in non-polar solvents, e.g. ether.
- About 98% of milk fat is a mixture of triacyl glycerides. There are also neutral lipids, fat-soluble vitamins and pigments (e.g. carotene, which gives butter its yellow colour), sterols and waxes.
- Fats supply the body with a concentrated source of energy: oxidation of fat in the body yields 9 calories/g.
- Milk fat acts as a solvent for the fat-soluble vitamins A, D, E and K and also supplies essential fatty acids (linoleic, linolenic and arachidonic).
- A fatty-acid molecule comprises a hydrocarbon chain and a carboxyl group (-COOH).
- In **saturated fatty acids** the carbon atoms are linked in a chain by single bonds.
- In **unsaturated fatty acids** there is **one double bond** and in **poly-unsaturated** fatty acids there is **more than one double bond**. Examples of each type of fatty acid are shown in the next Figure .

Structural formulae of four 18-carbon fatty acids varying in degree of saturation

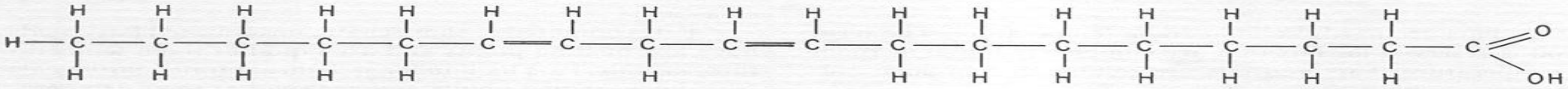
Stearic acid C18:0



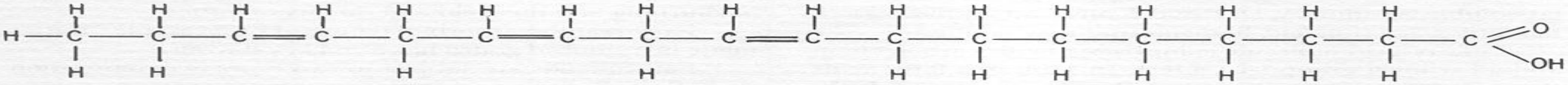
Oleic acid C18:1



Linoleic acid C18:2



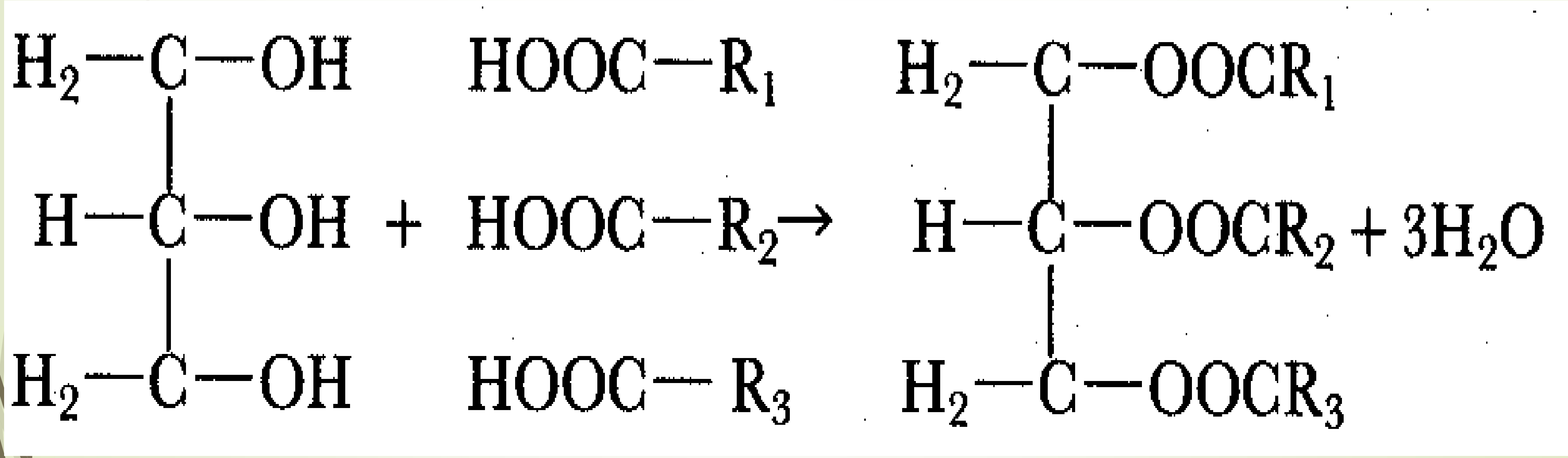
Linolenic acid C18:3



Conclusion

- Fatty acids can also vary in degree of unsaturation
  - C18:0 stearic (saturated)
  - C18:1 oleic (one double bond)
  - C18:2 linoleic (two double bonds)
  - C18:3 linolenic (three double bonds)
- The most important fatty acids found in milk - Triglycerides
- Formed by esterification reaction of Fatty acids with glycerol

Glycerol + fatty acids → triglyceride (fat) + water



Principal fatty acids found in milk triglycerides

	Molecular formula	Chain length	Melting point
Butyric	$CH_3(CH_2)_{2COOH}$	C_4	–8°C
Caproic	$CH_3(CH_2)_{4COOH}$	C_6	–2°C
Caprylic	$CH_2(CH_2)_{6COOH}$	C_8	16°C
Capric	$CH_3(CH_2)_{8COOH}$	C_{10}	31.5°C
Lauric	$CH_3(CH_2)_{10COOH}$	C_{12}	44°C
Myristic	$CH_3(CH_2)_{12COOH}$	C_{14}	58°C
Palmitic	$CH_3(CH_2)_{14COOH}$	C_{16}	64°C
Stearic	$CH_3(CH_2)_{16COOH}$	C_{18}	70°C
Arichidonic	$CH_3(CH_2)_{18COOH}$	C_{20}	
Oleic	$CH_3(CH_2)_{7CH}=CH(CH_2)_{7COOH}$	$C_{18:1}$	13°C
Linoleic	$CH_3(CH_2)_4(CH=CH.CH_2)_2(CH_2)_{6COOH}$	$C_{18:2}$	–5°C
Linolenic	$CH_3.CH_2(CH=CH.CH_2)_3(CH_2)_{6COOH}$	$C_{18:3}$	

Need to remember…

- ✓ The melting point and hardness of the fatty acid is affected by:
- The length of the carbon chain and the degree of unsaturation.
- ✓As chain length increases, melting point increases.
- ✓As the degree of unsaturation increases, the melting point decreases.
- Fats composed of short-chain, unsaturated fatty acids have low melting points and are liquid at room temperature, i.e. oils.
- Fats high in long-chain saturated fatty acids have high melting points and are solid at room temperature.
- Butterfat is a mixture of fatty acids with different melting points, and therefore does not have a distinct melting point. Since butterfat melts gradually over the temperature range of 0-40°C, some of the fat is liquid and some solid at temperatures between 16 and 25°C.
- The ratio of solid to liquid fat at the time of churning influences the rate of churning and the yield and quality of butter.

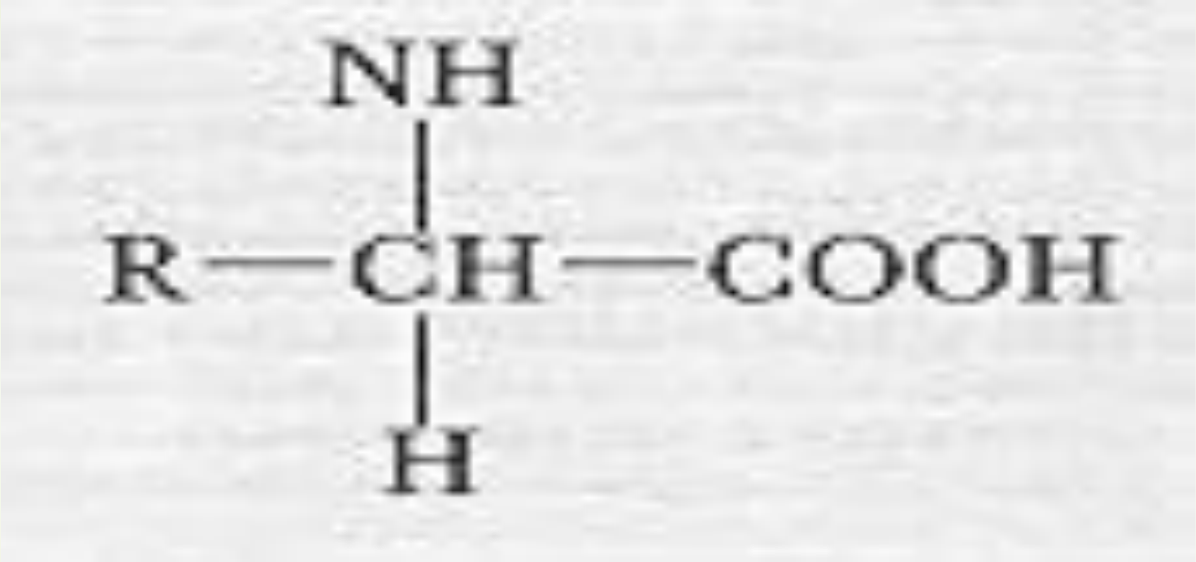
Quality of milk fat

- Fats readily absorb flavours. For example, butter made in a smoked gourd has a smokey flavour
- **Fats in foods are subject to two types of deterioration that affect the flavour of food products**
- *Hydrolytic rancidity:* In hydrolytic rancidity, fatty acids are broken off from the glycerol molecule by lipase enzymes produced by milk bacteria. The resulting free fatty acids are volatile and contribute significantly to the flavour of the product
- *Oxidative rancidity:* Oxidative rancidity occurs when fatty acids are oxidised. In milk products it causes tallowy flavours. Oxidative rancidity of dry butterfat causes off-flavours in recombined milk

Milk Proteins

- **Proteins** are an extremely important class of naturally occurring compounds that are essential to all life processes.
- They perform a variety of functions in living organisms ranging from providing structure to reproduction.
- Milk proteins represent one of the greatest contributions of milk to human nutrition.
- Proteins are polymers of amino acids. Only 20 different amino acids occur, regularly in proteins.

General Structure of Protein



- R represents the organic radical
- Each amino acid has a different radical and this affects the properties of the acid. The content and sequence of amino acids in a protein therefore affect its properties.
- Some proteins contain substances other than amino acids, e.g. lipoproteins contain fat and protein. Such proteins are called conjugated proteins:

Conjugated Proteins

- *Phosphoproteins:* Phosphate is linked chemically to these proteins-examples include casein in milk and phosphoproteins in egg yolk.
- *Lipoproteins:* These combinations of lipid and protein are excellent emulsifying agents. Lipoproteins are found in milk and egg yolk.
- *Chromoproteins:* These are proteins with a coloured prosthetic group and include haemoglobin and myoglobin.

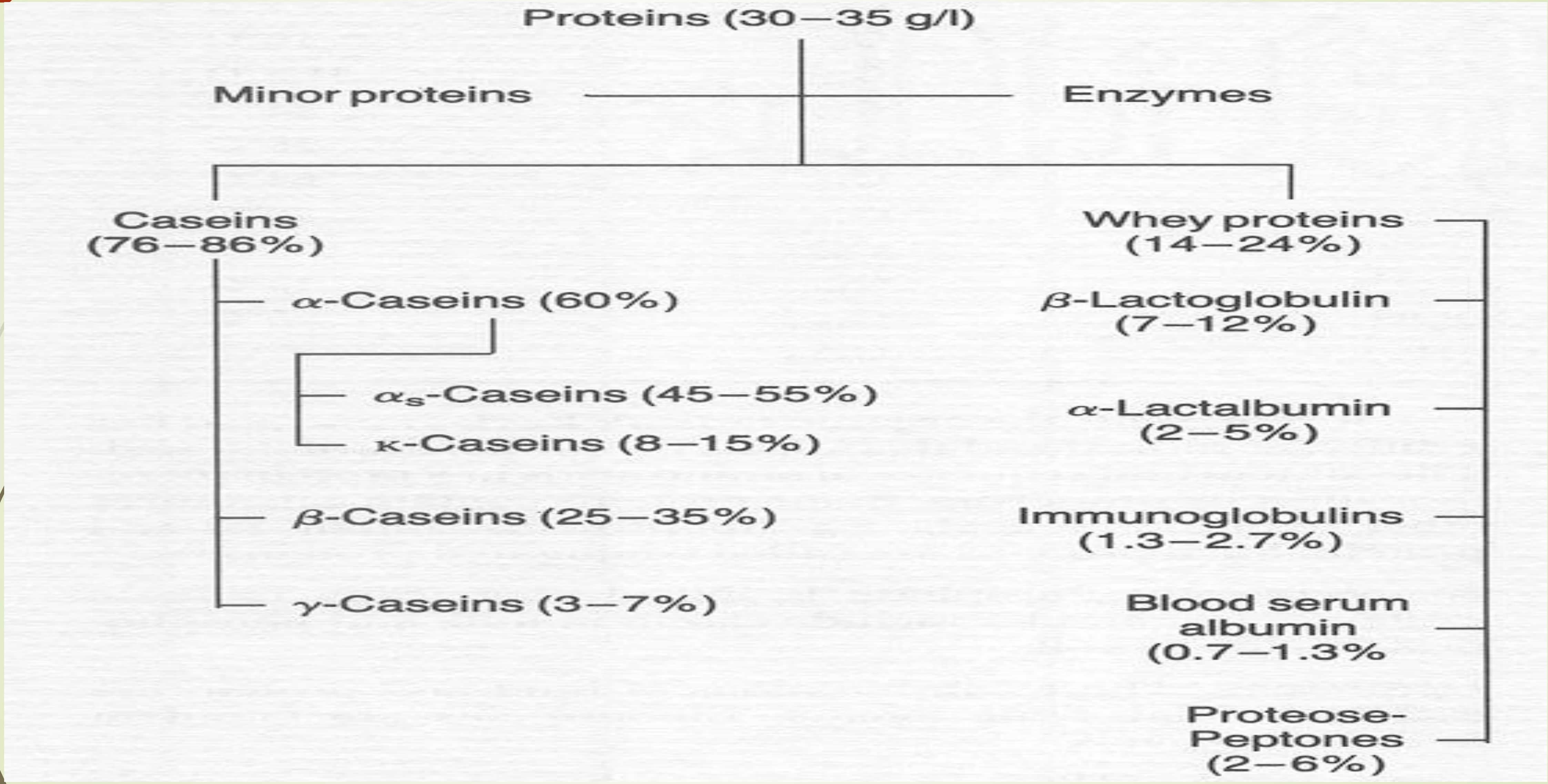
Casein

- Casein was first separated from milk in 1830, by adding acid to milk, thus establishing its existence as a distinct protein.
- In 1895 the whey proteins were separated into globulin and albumin fractions.
- It was subsequently shown that casein is made up of a number of fractions and is therefore heterogeneous.
- Casein is easily separated from milk, either by acid precipitation or by adding rennin.
- In cheese-making most of the casein is recovered with the milk fat. Casein can also be recovered from skim milk as a separate product.

Milk Protein-Casein

- **Casein** is dispersed in milk in the form of micelles. The micelles are stabilised by the K-casein.
- Caseins are hydrophobic but K-casein contains a hydrophilic portion known as the glycomacropeptide and it is this that stabilises the micelles. The structure of the micelles is not fully understood.
- When the pH of milk is changed, the acidic or basic groups of the proteins will be neutralised. At the pH at which the positive charge on a protein equals exactly the negative charge, the net total charge of the protein is zero. This pH is called the isoelectric point of the protein (pH 4.6 for casein).
- If an acid is added to milk, or if acid-producing bacteria are allowed to grow in milk, the pH falls. As the pH falls the charge on casein falls and it precipitates. Hence milk curdles as it sours, or the casein precipitates more completely at low pH.

Milk protein fractions



Whey proteins

- After the fat and casein have been removed from milk, one is left with whey, which contains the soluble milk salts, milk sugar and the remainder of the milk proteins.
- Like the proteins in eggs, whey proteins can be coagulated by heat. When coagulated, they can be recovered with caseins in the manufacture of acid-type cheeses.
- The **whey proteins** are made up of a number of distinct proteins, the most important of which are **β-lactoglobulin** and **lactoglobulin**.
- **β -lactoglobulin** accounts for about 50% of the whey proteins, and has a high content of essential amino acids.
- It forms a complex with K-casein when milk is heated to more than 75°C, and this complex affects the functional properties of milk.
- Denaturation of β -lactoglobulin causes the cooked flavour of heated milk.

Other milk proteins

- In addition to the major protein fractions outlined, milk contains a number of enzymes. The **main enzymes** present are **lipases**, which cause rancidity, particularly in homogenised milk, and **phosphatase** enzymes, which catalyse the hydrolysis of organic phosphates. **Measuring the inactivation of alkaline phosphatase is a method of testing the effectiveness of pasteurization of milk**.
- **Peroxidase** enzymes, which catalyse the breakdown of hydrogen peroxide to water and oxygen, are also present. **Lactoperoxidase** can be activated and use is made of this for milk preservation.
- Milk also contains **protease enzymes**, which catalyse the hydrolysis of proteins, and lactalbumin, bovine serum albumin, the immune globulins and **lactoferrin**, which **protect the young calf against infection**.

Milk carbohydrates

- **Lactose (Milk Sugar)** is the major carbohydrate fraction in milk. It is **made up** of two sugars, **glucose** and **galactose**
- The average lactose content of milk varies between 4.7 and 4.9%, though milk from individual cows may vary more.
- **Mastitis reduces lactose secretion**.
- Lactose is a source of energy for the young calf, and provides 4 calories/g of lactose metabolised.
- It is less soluble in water than sucrose and is also less sweet. It can be broken down to glucose and galactose by bacteria that have the enzyme β-galactosidase.
- The glucose and galactose can then be fermented to lactic acid. This occurs when milk goes sour.
- Under controlled conditions they can also be fermented to other acids to give a desired flavour, such as propionic acid fermentation in Swiss-cheese manufacture.

Lactose (Milk sugar)

- Lactose is present in milk in molecular solution. In cheese-making lactose remains in the whey fraction.
- It has been recovered from whey for use in the pharmaceutical industry, where its low solubility in water makes it suitable for coating tablets. It is used to fortify baby-food formula. Lactose can be sprayed on silage to increase the rate of acid development in silage fermentation.
- It can be converted into ethanol using certain strains of yeast, and the yeast biomass recovered and used as animal feed. However, these processes are expensive and a large throughput is necessary for them to be profitable.
- Heating milk to above 100oC causes lactose to combine irreversibly with the milk proteins. This reduces the nutritional value of the milk and also turns it brown.

Continued

- Special processing is required to crystallise lactose when manufacturing products such as instant skim milk powders.
- Some people are unable to metabolise lactose and suffer from an allergy as a result. Pre-treatment of milk with lactase enzyme breaks down the lactose and helps overcome this difficulty.
- In addition to lactose, milk contains traces of glucose and galactose. Carbohydrates are also present in association with protein. K-casein, which stabilises the casein system, is a carbohydrate-containing protein.

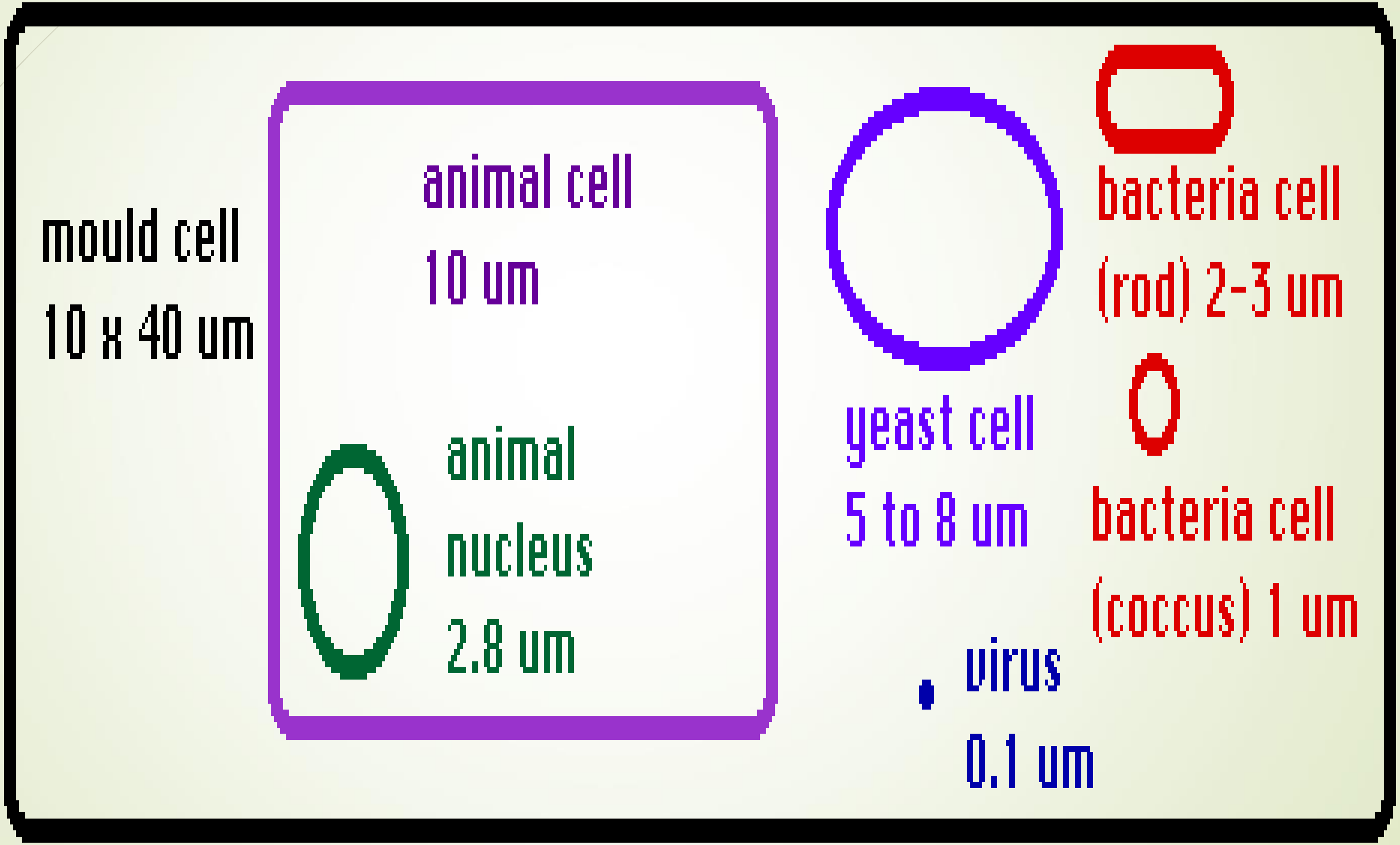
Minor milk constituents

- Milk also contains a number of organic and inorganic compounds in small or trace amounts, some of which affect both the processing and nutritional properties of milk.
- **Milk salts**: mainly chlorides, phosphates and citrates of sodium, calcium and magnesium.
- **Milk vitamins:** Milk contains the fat-soluble vitamins A, D, E and K in association with the fat fraction and water-soluble vitamins B complex and C in association with the water phase.
- **Vitamins** are unstable and processing can therefore reduce the effective vitamin content of milk.

Milk Microbiology (Dead by your own on Self-Reading Assignment)

- Milk drawn from a healthy milk animal already contains some bacteria.
- Most of the changes which take place in the flavor and appearance of milk, after it is drawn from udder are the results of the activities of microbes.
- These microbes are of two types i.e. **favorable** - which brings favorable changes in flavor & appearance while **pathogenic** - which may cause diseases.
- The favorable are carefully propagated while pathogenic (unfavorable) are destroyed to make the milk & its products safe for human consumption.

Basic Microbiology



Microorganisms

- Microorganisms are living organisms that are individually too small to see with the naked eye.
- The unit of measurement used for microorganisms is the micrometer (µ m); 1 µ m = 0.001 millimeter; 1 nanometer (nm) = 0.001 µ m.
- Microorganisms are found everywhere (ubiquitous) and are essential to many of our planets life processes.
- With regards to the food industry, they can cause spoilage, prevent spoilage through fermentation, or can be the cause of human illness.
- Several classes of microorganisms, of which bacteria and *fungi* (*yeasts and moulds*)

Bacteria

- Bacteria are relatively simple single-celled organisms. One method of classification is by shape or morphology:
- **Cocci:**
- Spherical shape
- 0.4 - 1.5 µ m
- Examples: **staphylococci** - form grape-like clusters; **streptococci** - form bead-like chains
- **Rods:**
- 0.25 - 1.0 µ m width by 0.5 - 6.0 µ m long
- Examples: **bacilli** - straight rod; **spirilla** - spiral rod

Bacteria

- There exists a bacterial system of taxonomy, or classification system, that is internationally recognized with family, genera and species divisions based on genetics.
- **Some bacteria have the ability to form resting cells known as endospores**. The **spore forms** in times of environmental stress, such as **lack of nutrients** and **moisture needed** for **growth**, and thus is a survival strategy.
- **Spores have no metabolism and can withstand adverse conditions such as heat, disinfectants, and ultraviolet light**.
- When the environment becomes favorable, the spore germinates and giving rise to a single vegetative bacterial cell.
- Some examples of **spore-formers** important to the **food industry** are members of ***Bacillus*** and ***Clostridium*** generas.

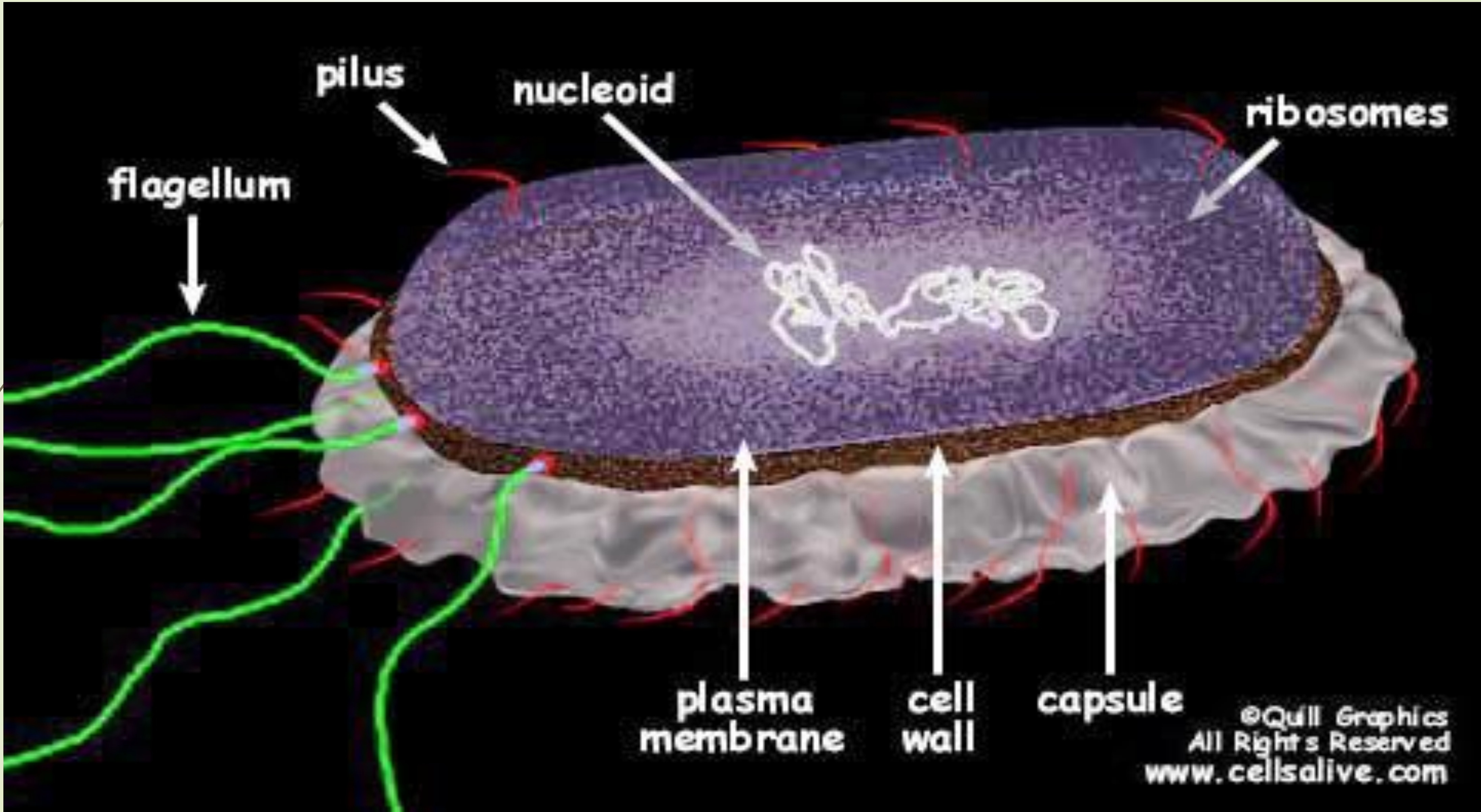
Important microbes found in milk

- **Bacteria:-** Are microscopic, unicellular, occurs in the form of spherical, cylindrical or spiral cells.
- Size 1-5μ. Spore forming bacteria produce trouble in dairy industry because of their resistance to pasteurization & sanitization produces.
- Greater the bacteriological count in milk, the lower is its bacteriological quality.
- **There is always bacteriological standards of raw milk and processed products**.

QSAE:ES 548:2001 or Draft COMESA/EAST African Standards

WWW.dairyafrica.com (ESADA)

Bacterial Cell Structure (Model)



International bacteriological standards of raw milk

SPC/ml (org)	Grade
Not exceeding 2,00,000	Very good
Between 2,00,000 and 10,00,000	Good
Between 10,00,000 and 50,00,000	Fair
Over 50,00,000	Poor

*Pasteurized milk should have a SPC/ml (org) not exceeding 30,000.

Microorganisms in milk

- **Spoilage Microorganisms**
- **Pathogenic Microorganisms**
- **Moulds:-** Multi-cellular, at maturity are as Mycelium. Useful in cheese making which is responsible for defects in butter and other milk products. Most spores of moulds are destroyed by pasteurization.
- **Yeast:-** Unicellular, larger than bacteria. Destroyed during pasteurization.
- **Viruses:** Are ultra-microscopic forms of like can be destroyed by pasteurization or higher heat treatment.

GROWTH OF MICRO-ORGANISMS

- Bacteria multiply during production and holding of milk, depending on storage time and conditions.
- The changes take place in the physico-chemical properties of milk are result of the activities of the individual microbial cells during their period of growth and reproduction or of substances produced during such activity.

a. Stages of growth (The four phase of bacterial growth):-

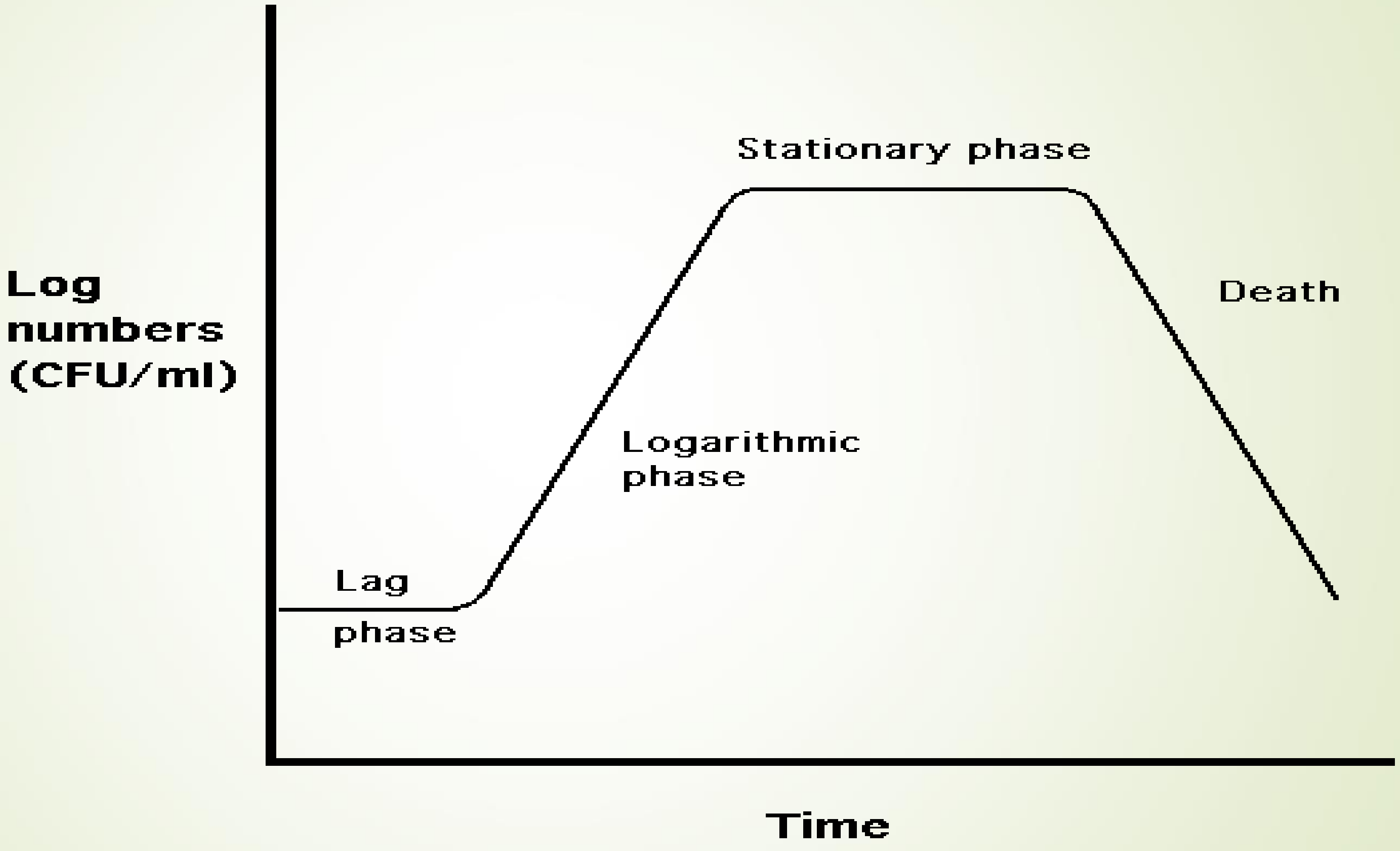
i. **Lag phase** (Phase of adjustment)

ii . **Log phase** (Accelerated growth phase)

iii. **Stationary phase**

iv. **Death Phase**

Survival and growth of microorganisms in food



Hypothetical bacterial growth curve.

Factors Influencing Bacterial Growth

- **Nutrients** - Milk and its products are good food source, provides all food requirements.
- **Water** -Bacteria can't grow with out water. a_w can be as indicator for the availability of water
- **Oxygen**– Supplies O2 to aerobic bacteria and moulds.
- **Acidity** or pH - Preferably range 5.6 to 7.5.
- **Temperature** - Important means for controlling growth.
- According to their optimum growth temperature, bacteria can be classified into :
  - **Psychotropic** - can grow at refrigeration temp.< 7^0C.
  - **Mesophilic** -can grow at temp. 20-40^0C.
  - **Thermophilic** - can grow at temp. above 50^0C. (Optimum 45^o C)

Products of Microbial Growth

- Enzymes
- Decomposition products (fats, proteins, sugars)
- Pigments
- Toxins
- Miscellaneous changes.

Results of Microbial Growth in Milk (Milk spoilage indicators)

- ☑ Souring:- Most common, due to transformation of lactose into lactic acid, other volatile acids & compounds, principally by lactic acid bacteria.
- ☑ Souring & gassiness:- Caused by ***E coli*** group, indicates contamination of milk and its products.
- ☑ Aroma production:- Due to production of desirable flavour compounds such as diacetly.
- ☑ Proteoloysis:- Protein decomposition leading to unpleasant odor.
- ☑ Ropiness:- Long threads of milk are formed while pouring. Mainly Alkaligenous viscus.
- ☑ Sweet curdling:- Due to production of a remain like enzyme curdles milk without souring.

Methods for the destruction of Micro-organisms

- **Heat** : Most widely used. Pasteurization & sterilization.
- **Ionizing radiation** - Such as ultraviolet rays etc.
- **High frequency sound waves** – Supersonic and ultrasonic.
- **Electricity** – Microbes are destroyed actually by heat generated.
- **Pressure** -Should be about 600 times greater than atmospheric pressure.
- **Chemicals** – Includes acids, alkalis, hydrogen peroxide, halogens etc
- **Advanced methods of food preservation**

Antimicrobial Constituents

- As part of the natural protection against microorganisms, many **foods have antimicrobial factors.**
- **Milk** has several nonimmunological proteins which inhibit the growth and metabolism of many microorganisms including the following most common:
  - **Lactoperoxidase**
  - **Lactoferrin**
  - **Lysozyme**
  - **Xanthine**

Action of Microbes on Milk and milk products (Home take Assignment)

- **Further reading on :**

The action of microorganisms on milk and milk products (*Dairy microbiology*): Milk spoilage

- **Prepare in the form of table**
- **Microbes (Diploccci, micrococci, staphylococci etc)**
- **Action**
- **Result**
- **Indictors of spoilage**

Coliforms

- **Coliforms** are facultative anaerobes with an optimum growth at 37° C.
- **Coliforms are indicator organisms**; they are closely associated with the **presence of pathogens** but not necessarily pathogenic themselves.
- They also can cause rapid spoilage of milk because they are able to ferment lactose with the production of acid and gas, and are able to degrade milk proteins. They are **killed by HTST treatment, therefore, their presence after treatment is indicative of contamination**.
- *Escherichia coli* is an example belonging to this group.

Spoilage Microorganisms in Milk (Home take assignment)

- **The microbial quality of raw milk is crucial for the production of quality dairy foods.**
- **Spoilage** is a term used to describe the deterioration of a foods' texture, colour, odour or flavour to the point where it is unappetizing or unsuitable for human consumption. Microbial spoilage of food often involves the degradation of protein, carbohydrates, and fats by the microorganisms or their enzymes.
- In milk, the microorganisms that are principally involved in spoilage are psychrotrophic organisms. Most psychrotrophs are destroyed by pasteurization temperatures, however, some like *Pseudomonas fluorescens*, *Pseudomonas fragi* can produce proteolytic and lipolytic extracellular enzymes which are heat stable and capable of causing spoilage.
- Some species and strains of *Bacillus*, *Clostridium*, *Cornebacterium*, *Arthrobacter*, *Lactobacillus*, *Microbacterium*, *Micrococcus* , and *Streptococcus* can survive pasteurization and grow at refrigeration temperatures which can cause spoilage problems.

Pathogenic Microorganisms in Milk

- Hygienic milk production practices, proper handling and storage of milk, and mandatory pasteurization has decreased the threat of milk-borne diseases such as tuberculosis, brucellosis, and typhoid fever.
- There have been a number of food-borne illnesses resulting from the ingestion of raw milk, or dairy products made with milk that was not properly pasteurized or was poorly handled causing post-processing contamination. The following bacterial **pathogens** are still of concern today in raw milk and other dairy products:
- ***Bacillus cereus***
- ***Listeria monocytogenes***
- ***Yersinia enterocolitica***
- ***Salmonella* spp.**
- ***Escherichia coli* O157:H7**
- ***Campylobacter jejuni***
- It should also be noted that moulds, mainly of species of *Aspergillus* , *Fusarium* , and *Penicillium* can grow in milk and dairy products. If the conditions permit, these moulds may produce **mycotoxins which can be a health hazard.**

Starter Cultures

- **Starter cultures** are those microorganisms that are used in the production of cultured dairy products such as yogurt and cheese. The natural microflora of the milk is either inefficient, uncontrollable, and unpredictable, or is destroyed altogether by the heat treatments given to the milk.
- **A starter culture can provide particular characteristics in a more controlled and predictable fermentation**.
- The primary function of lactic starters is the production of lactic acid from lactose. Other **functions of starter cultures** may include the following:
  - **Flavour, aroma, and alcohol production**
  - **Proteolytic and lipolytic activities**
  - **Inhibition of undesirable organisms**

Starter Culture Preparation

- Commercial manufacturers provide starter cultures in lyophilized (freeze-dried), frozen or spray-dried or pellet forms. The dairy product manufacturers need to inoculate the culture into milk or other suitable substrate.
- There are a number of steps necessary for the propagation of starter culture ready for production:
- **Commercial culture**
- **Mother culture** - first inoculation; all cultures will originate from this preparation
- **Intermediate culture** - in preparation of larger volumes of prepared starter
- **Bulk starter culture** - this stage is used in dairy product production
- ✓ **<u>Bacteriophages</u>: Viruses which attack and destroy most of the lactic acid bacteria which prevents normal ripening** . In yoghurt production the presence of Bacteriophages can kill useful LAB.
- ✓ **The bacterial cell ruptures and dies as the new bacteriophages are released.**

Detection and Enumeration of Microorganisms

- There are several methods for detection and enumeration of microorganisms in food.
- The method that is used depends on the purpose of the testing.
- **Direct Enumeration:** Using direct microscopic counts (DMC)
- Identification through staining and observation of morphology also possible with DMC
- **Metabolic Activity Measurement:** **Dye reduction tests such as resazurin or methylene blue dye reduction**,**acid production, electrical impendence etc.**
- **Cellular Constituents Measurement:** Using the **luciferase** test to measure **ATP**
- **PCR –Machine**: Normal & Real time-The latest technology

....Covered topics

- Milk composition, factors and milk chemistry:
  - Physical status of milk
  - Chemical composition of major milk components
  - pH and Acidity
  - Milk constituents
- Microbiology of milk and milk products
  - Phases of bacterial growth
  - Factors affecting bacterial growth

Next Lecture no. 2

- Milk separation, standardization
- Working principles of Pasteurizer, Homogenizer and others
- Fluid milk production line and its technology
- Dairy calculations
- Cream and Butter Processing Technology

Milk Processing

- Diversified milk products
- ☑ **Fluid milk**
  - Pasteurized milk, Cultured milk, Flavored milk
- ☑ **Evaporated and Concentrated milks**
  - Evaporated milk, sweetened condensed milk
- ☑ **Dried milk**
  - Skim milk powder
- ☑ Fermentation/cultured milk
  - Yogurt, sour cream, cultured butter milk
- ☑ **Other milk products**
  - Cheese, Butter
  - Ice Cream, Sour cream and Weaning foods
- ☑ **Imitation milk**-contains no milk products at all
  - It is composed of water, vegetable oil, syrup, sugar, preservatives, stabilizers and emulsifiers. (Vitam.+ Minerals)

Fluid milk processing

- Raw milk collection, Bulking, transpiration,
- Receiving and storage
- Cleaning and decreaming (Separator)
- Homogenization
- Fat standardization
- Heat Treatment
- Chilling (Heat exchanger)
- Intermediate storage
- Filling/Packing

Raw Milk Quality and Storage

- Chemical, bacteriological, and temperature standards for **Grade A raw milk for pasteurization**, ultra-pasteurization or aseptic processing
- Temperature: 45°F or less within 2 h after milking
- Bacterial counts: <100,000 cfu/ml for individual farm milk and <300,000/ml as commingled milk prior to pasteurization
- Somatic Cell Counts: <750,000/ml
- Antibiotic presence: negative
- Storage time at plant max. 72h and Longer holding times allow growth of psychrophilic bacteria which can secrete heat-resistant proteases and lipases

Bacteria that limit milk shelf-life of milk and Milk products

- ***Lipolytic and proteolytic psychrotrophs*** - heat resistant enzymes - ex. *Pseudomonas fluorescens*
- ***Psychrotrophic spore formers*** (t***hermoducrics***) - heat resistant spores - ex. *Bacillus cereus*

Thermization (Lewis and Heppell, 2000)

- 57-68°C for 15 seconds
- Only effective if cooled to 4°C after treatment
- Applied to raw milk that needs to be stored for several days prior to use
- Purpose: reduce gram-negative psychrotrophic spoilage organisms (enzyme production)

Clarification and Clearing

- **Clarification**: removal of small particles - straw, hair etc. from milk; 2 lb/2,642 gal - based on density
- **"Bactofugation":** Centrifugal separation of microorganisms from milk: - Bacteria and particularly spores have higher density than milk
- **Two-stage centrifugation** can reduce spore loads up to >99%
- **Optimal temperature** for clarification is 55-60°C

Microfiltration

- **Microfilter membranes** of 1.4 µm or less can lead to reduction of bacteria - and spores up to 99.5-99.99%.

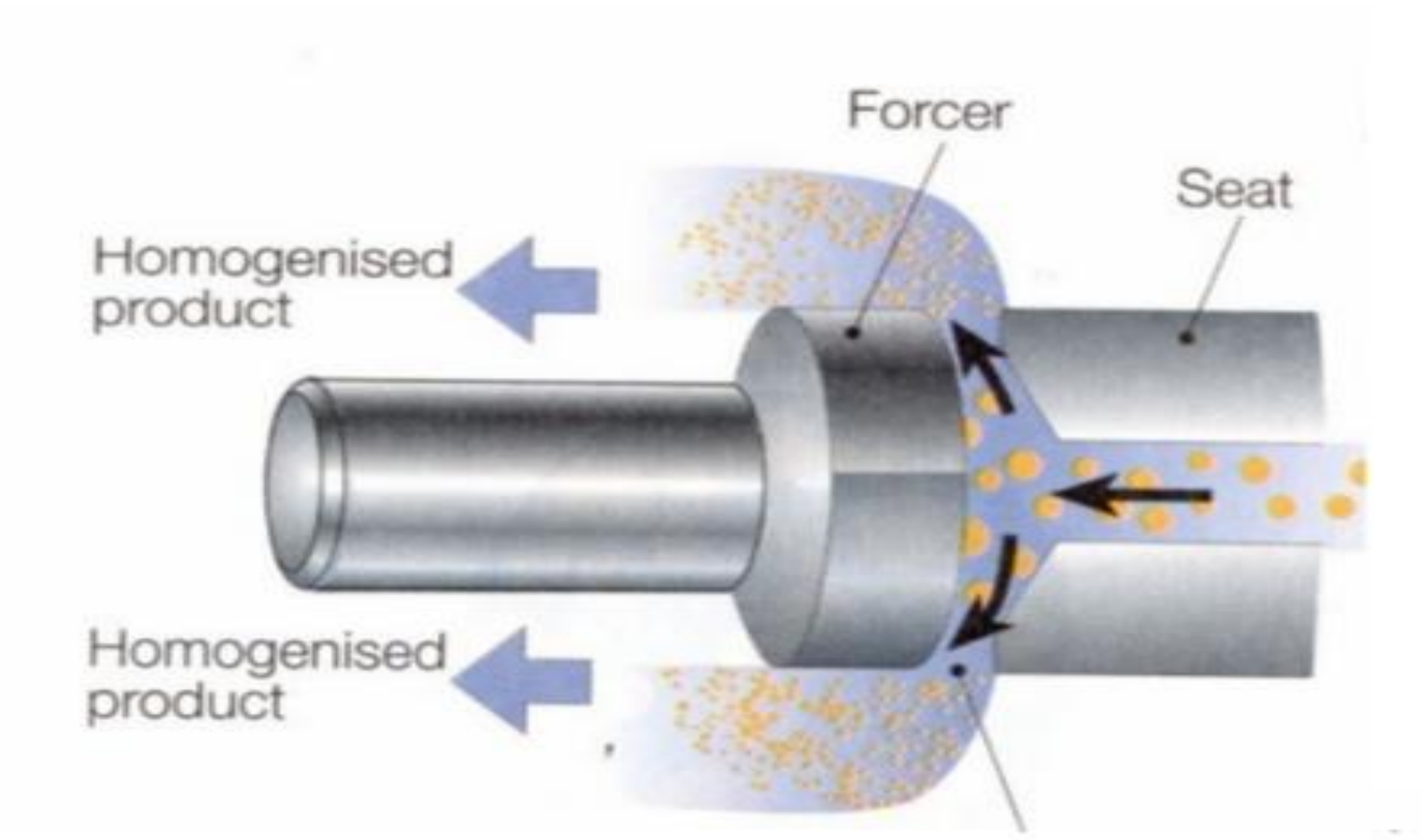
Milk Fat Standardization/Decreaming

- **Separation of skim milk** (about 0.05% fat) and cream (35-40% fat)
- Based on the fact that cream has lower density than skim milk
- **Centrifugal separators** are generally used today.
- **Standardization of fat content:**
  - **Adjustment of fat content of milk or a milk product** by addition of cream or skim milk to obtain a given fat content.

Homogenization

- **Treatment of milk or a milk product** to insure breakup of fat globules such that no visible cream separation occurs after 48 h at 40°F (4.4°C)
- **Effects of homogenization**: No cream line formation due to smaller fat globules – Whiter color – More full-bodied flavor, better mouthfeel.
- **Process requirements**: Homogenization most efficient when fat phase is in a liquid state
- Cream >12% fat cannot be homogenized at normal pressure, high pressure homogenization process is necessary.
- **Homogenization** is a mechanical process where milk is forced through a small passage at high velocity.

Homogenization Process



From the "Dairy Processing Handbook" 1995. Tetra Pak

Pasteurization

- **Purpose:** Inactivation of bacterial pathogens (target organisms *Coxiella burnettii*)
- **Assurance of longer shelf life** (inactivation of most spoilage organisms and of many enzymes)
- Pasteurization – Heat treatment of 72°C (161°F) for 15 sec (HTST) or 63°C (145°F) for 30 min (or equivalent)
- Does not kill all vegetative bacterial cells or spores (Bacillus spp. and Clostridium spp.)
- **Pasteurization temperature is continuously recorded**

Efficacy and Efficiency of Pasteurization process in the Dairy Industry

- Prior to pasteurization (1938) : milk borne outbreaks constituted 25% all disease outbreaks
- Today: milk products associated with < 1%
- How do measure **Efficacy and efficiency** of pasteurization process in dairy plant?

Heat Treatment

- Standards for Grade A pasteurized milk and milk products
- Temperature: Cooled to 45°F or less
- Bacterial counts: <20,000 cfu/ml
- Coliform Counts: <10/ml
- Phosphatase: < 1µg/ml
- Antibiotic presence: negative

Heat Treatment (Con't)

- Ultra pasteurization: Thermal processing at 138°C (280°F) for at least 2 seconds.
  - UP milk: ultra-pasteurized and "non-aseptically" packaged, refrigerated storage.
  - UHT milk: ultra-High-pasteurized and aseptically packaged, storage at room temperature; avoid recontamination.
- Standards for Grade A aseptically processed milk (UHT)
  - Temperature: none
  - Bacterial counts: no growth
  - Antibiotic presence: negative

Vitamin Fortification

- Vitamin Fortification: Preferably after separation
- Has to occur before pasteurization
- Can be continuous (using a metering pump) or batch addition

Filling/Packaging

- **Functions of packaging:**
- Enable efficient food distribution
- Maintain product hygiene
- Protect nutrients and flavor
- Reduce food spoilage
- Convey product information

Different containers

- Glass bottles (translucent vs. dark): Can be reusable or recyclable
- Plastic containers
- Cartons, and Plastic bags **(Various package types)**

Shelf Life of Heat Treated Fluid Milk

- Shelf life depends on:
  - Raw milk quality (bacterial and chemical quality)
  - Processing conditions
  - Post-processing storage
- Loss of taste and vitamins by light exposure:
  - Light-impermeable containers
- Extended Shelf life (ESL) milk
  - No single, specific definition of ESL
  - Pasteurized milk with a shelf life beyond the current typical shelf life of these products (10 - 14 days)
  - Generally involves measures to eliminate or minimize "post-pasteurization" contamination

Fluid Milk Processing

Raw milk storage

↓

Cleaning and decreaming (Separator)

↓

Homogenization

↓

Fat standardization

↓

Heat Treatment

↓

Chilling (Heat exchanger)

↓

Intermediate storage

↓

Filling/Packing

References

- Dairy Processing Handbook, 1995. Tetra Pak

- Please, read more in detail and take notes
- *Youtube* on dairy processing technology

Milk Separation

- ✓Cream separation
- ❑ Gravity separation

$$V = \frac{r^2 (d_1 - d_2) g}{9n}$$

Cream separation

- Centrifugal separation

$$V = \frac{r^{2}\left(d_{1}-d_{2}\right) r_{1}}{9n} w^{2}$$

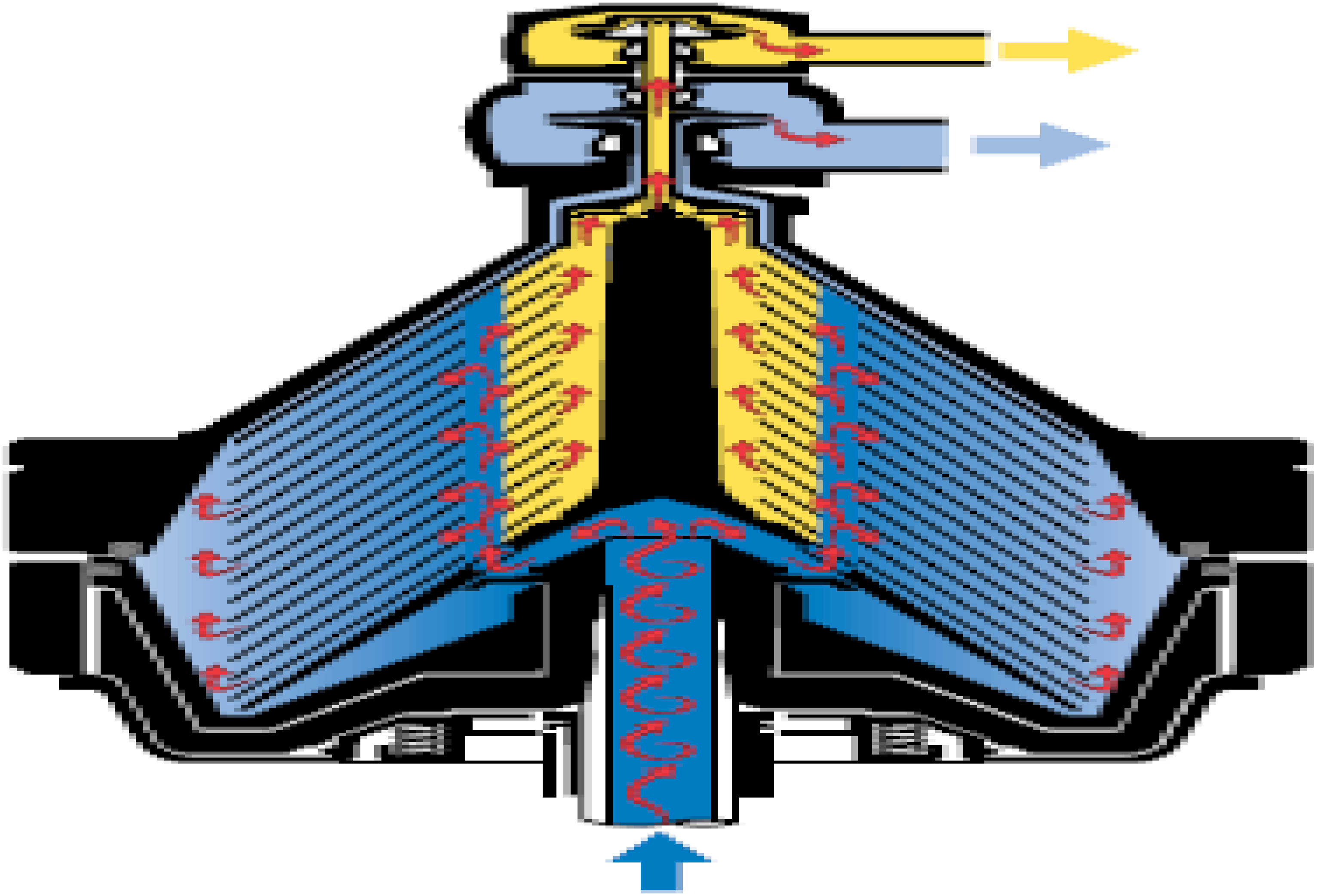
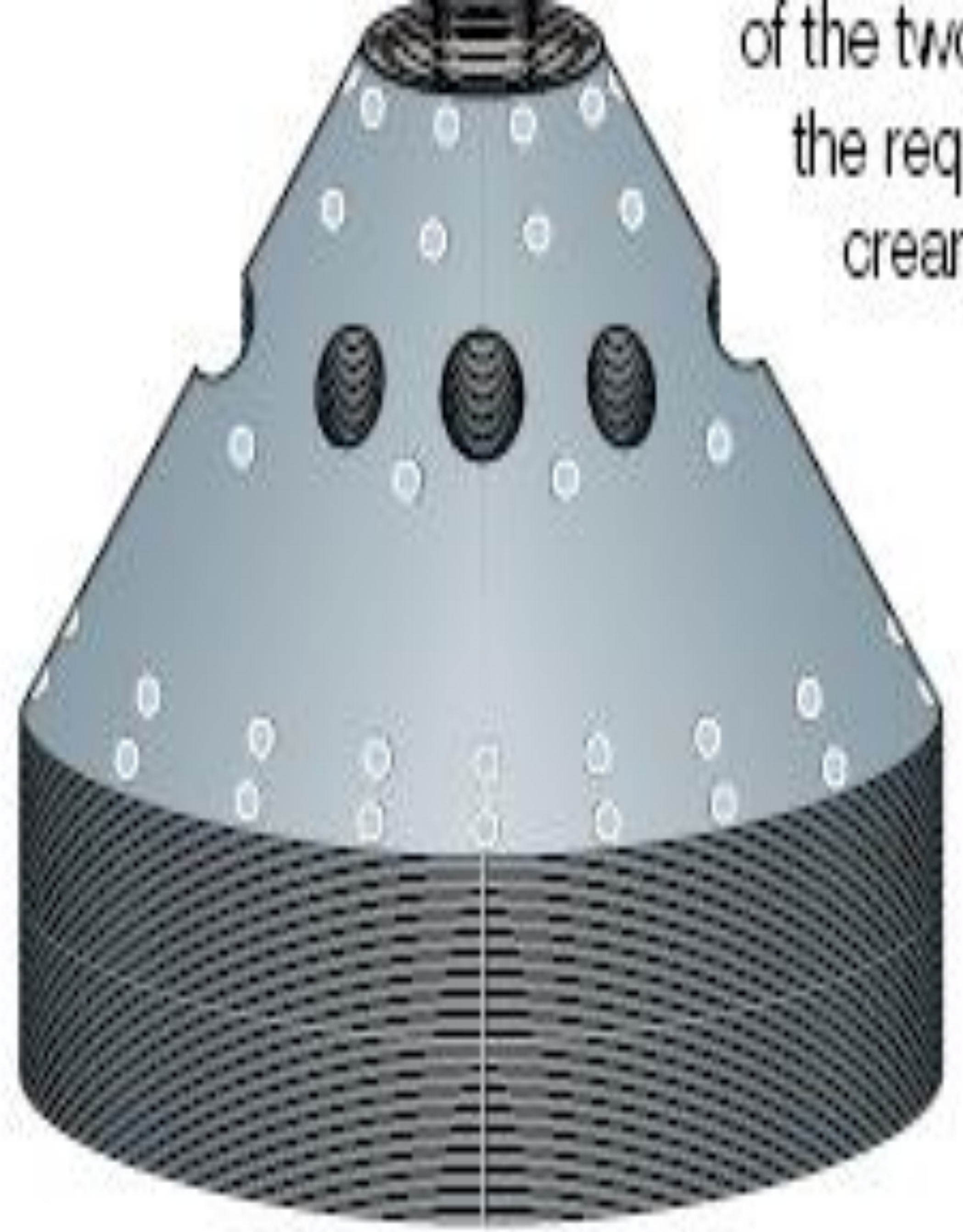


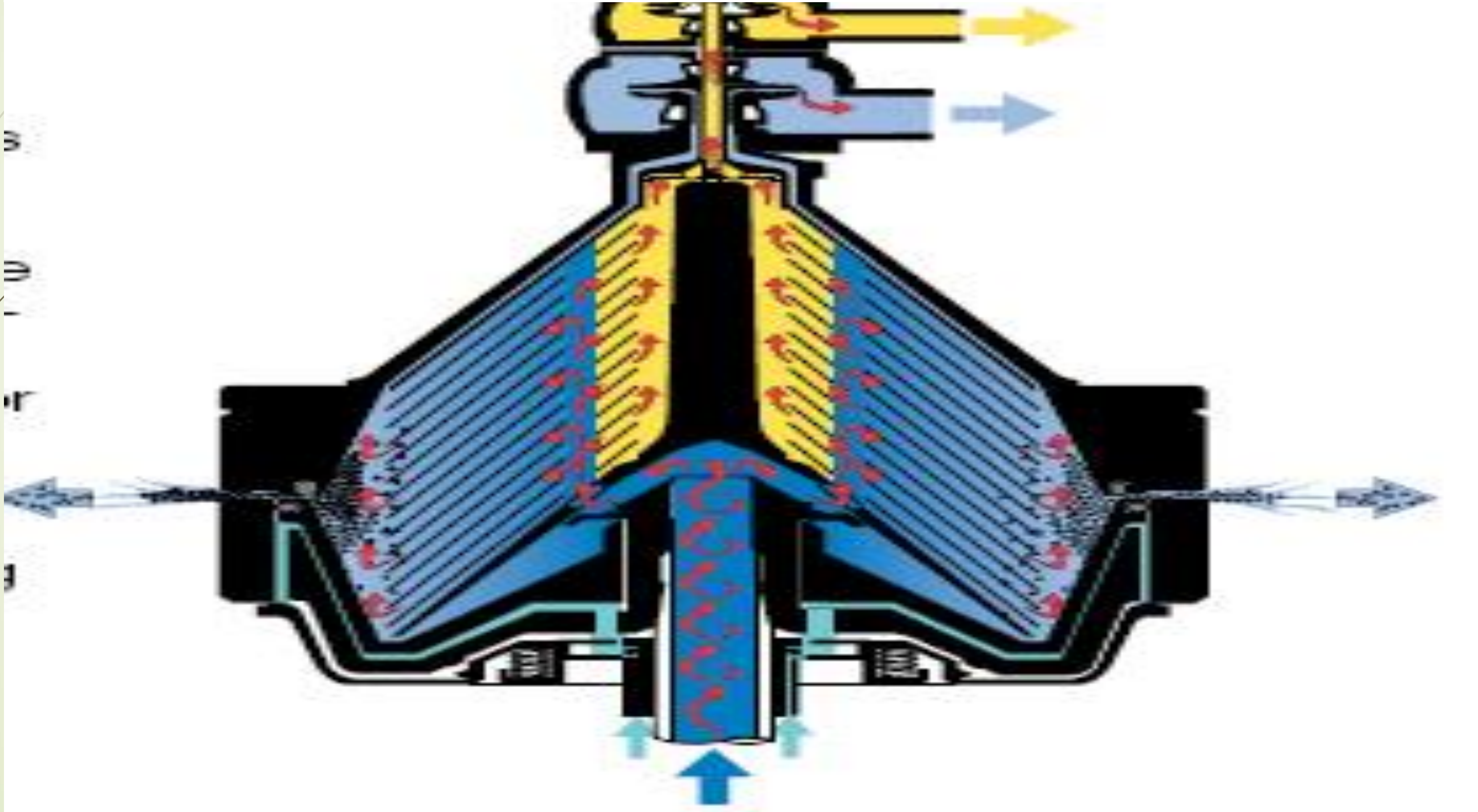
Fig. 6.2.19 In a centrifugal separator bowl the milk enters the disc stack through the distribution holes.



of the two flows in order to obtain the required fat content in the cream.

Fig. 6.2.21 *Disc stack with distribution holes and caulks.*

Fig. 6.2.22 *Solids ejection by short opening of the sedimentation space at the periphery of the bowl.*



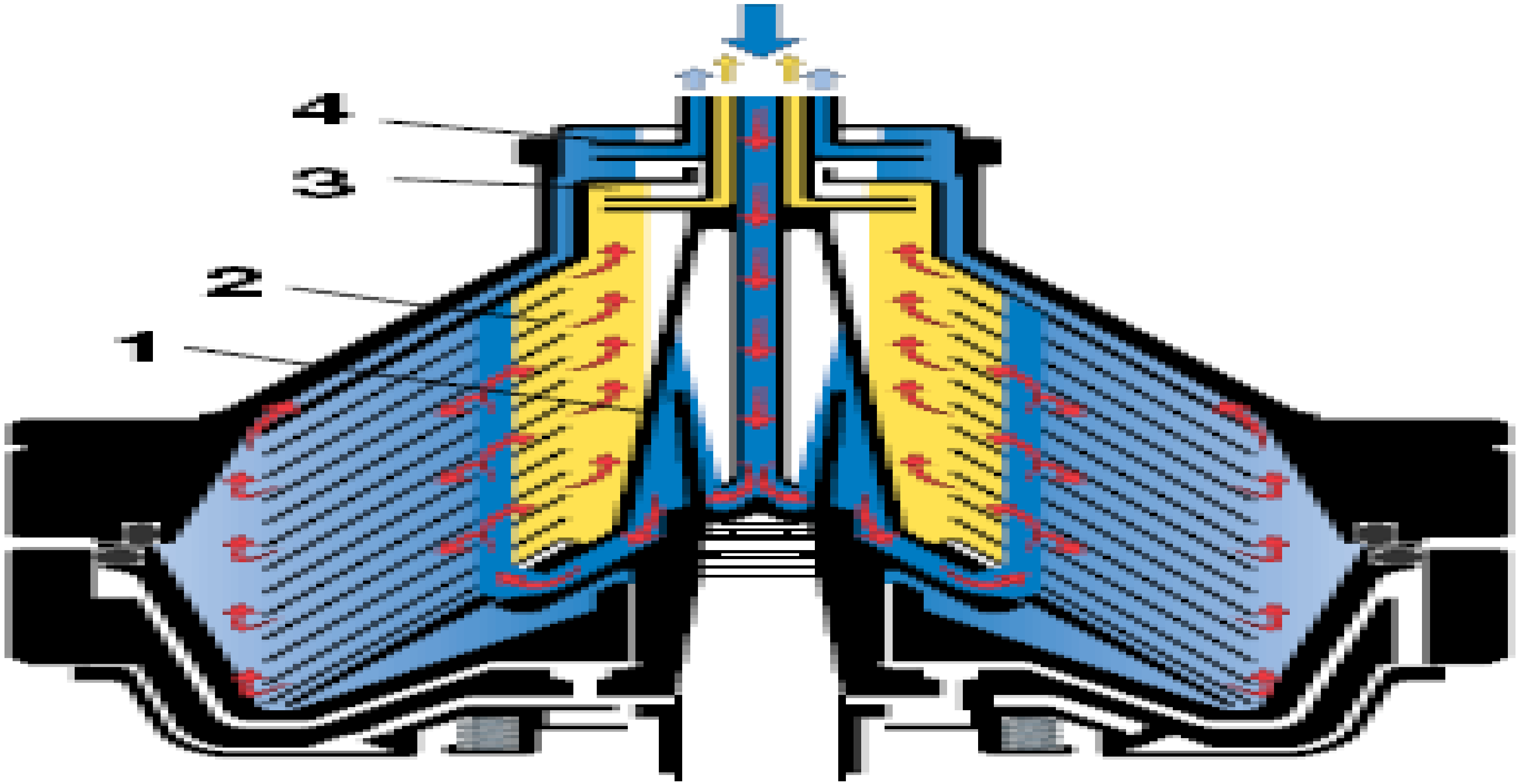
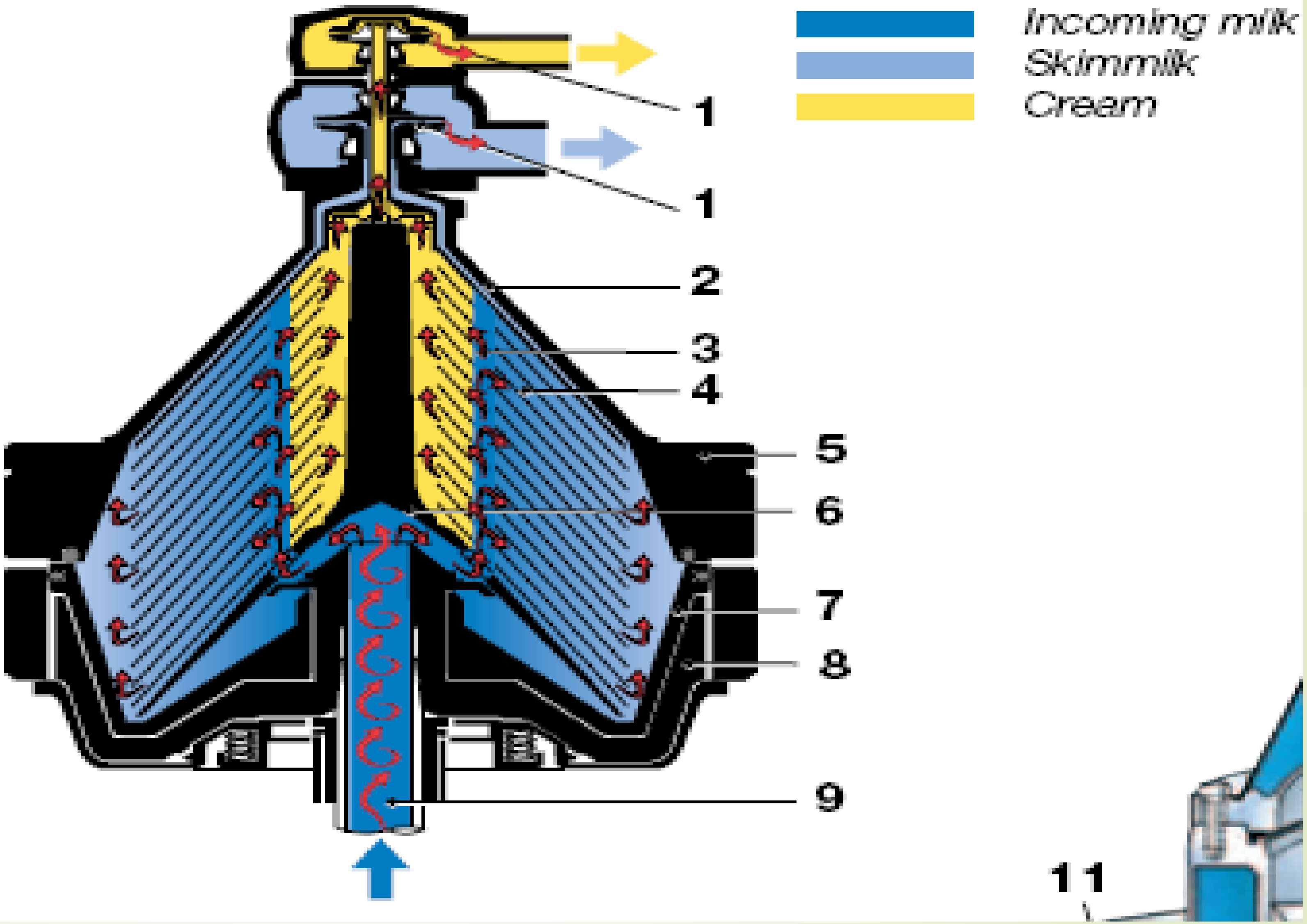


Fig. 6.2.23 Semi-open (paring disc) self-cleaning separator.
1 Distributor
2 Disc stack
3 Cream paring chamber
4 Skimmilk paring chamber

1 Outlet pumps
2 Bowl hood
3 Distribution hole
4 Disc stack
5 Lock ring
6 Distributor
7 Sliding bowl bottom
8 Bowl body
9 Hollow bowl spindle



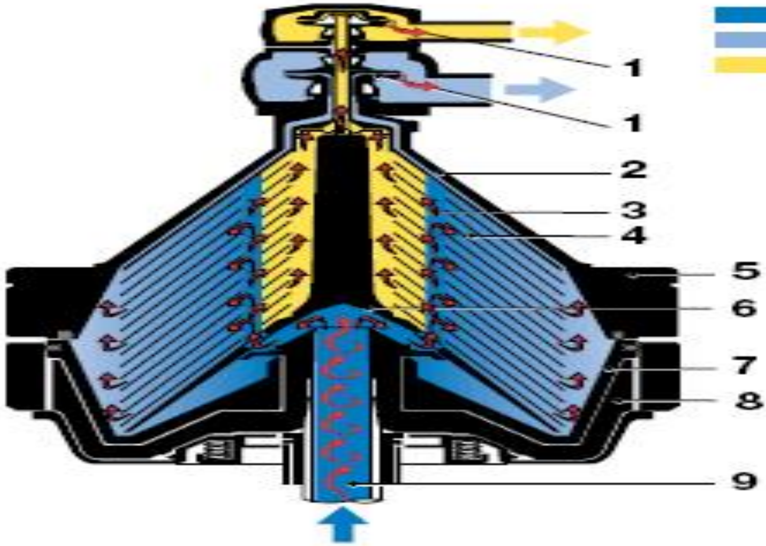


Fig. 6.2.25 Section through the bowl with outlets of a modern hermetic separator

1 Outlet pumps
2 Bowl hood
3 Distribution hole
4 Disc stack
5 Lock ring
6 Distributor
7 Sliding bowl bottom
8 Bowl body
9 Hollow bowl spindle

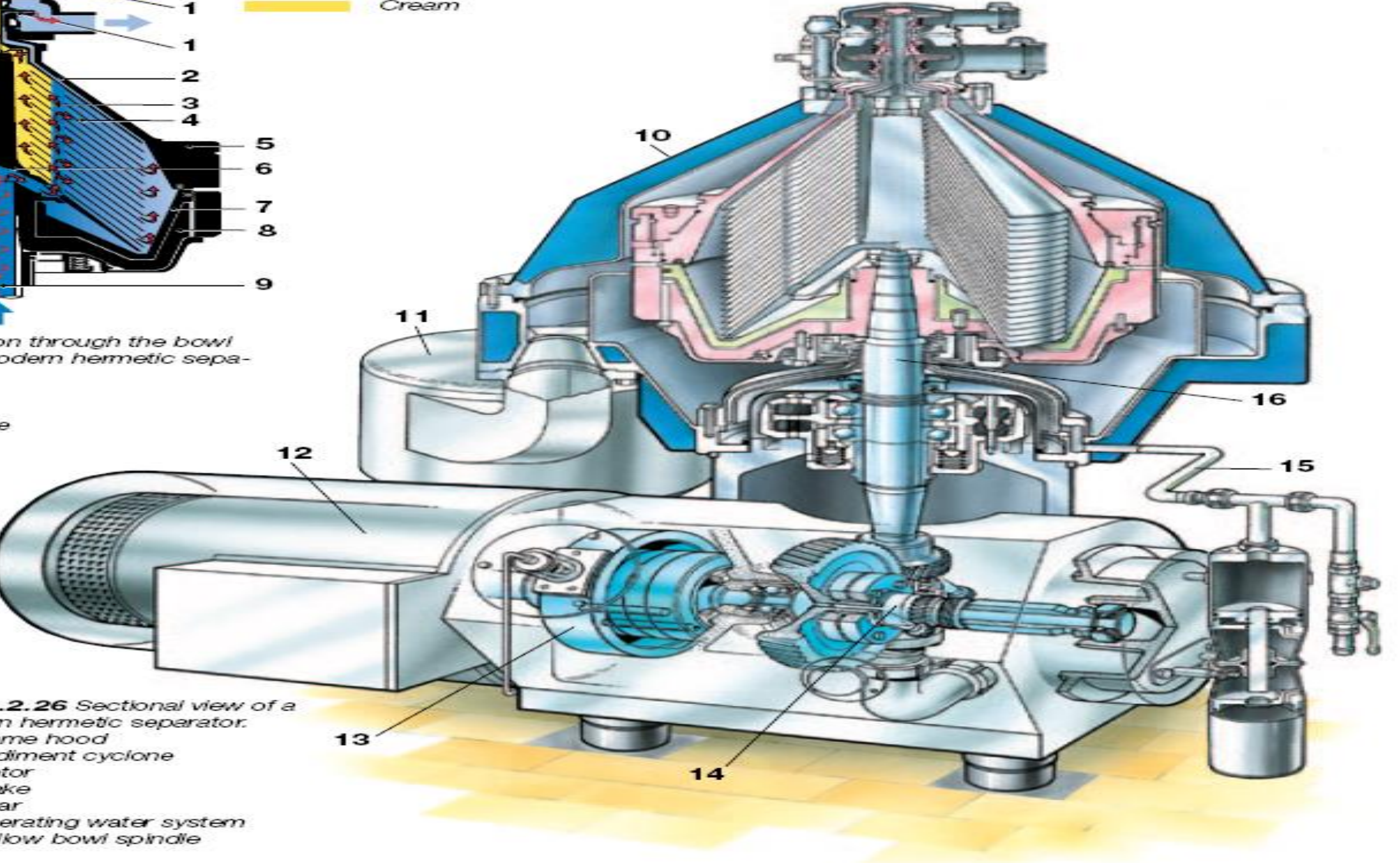
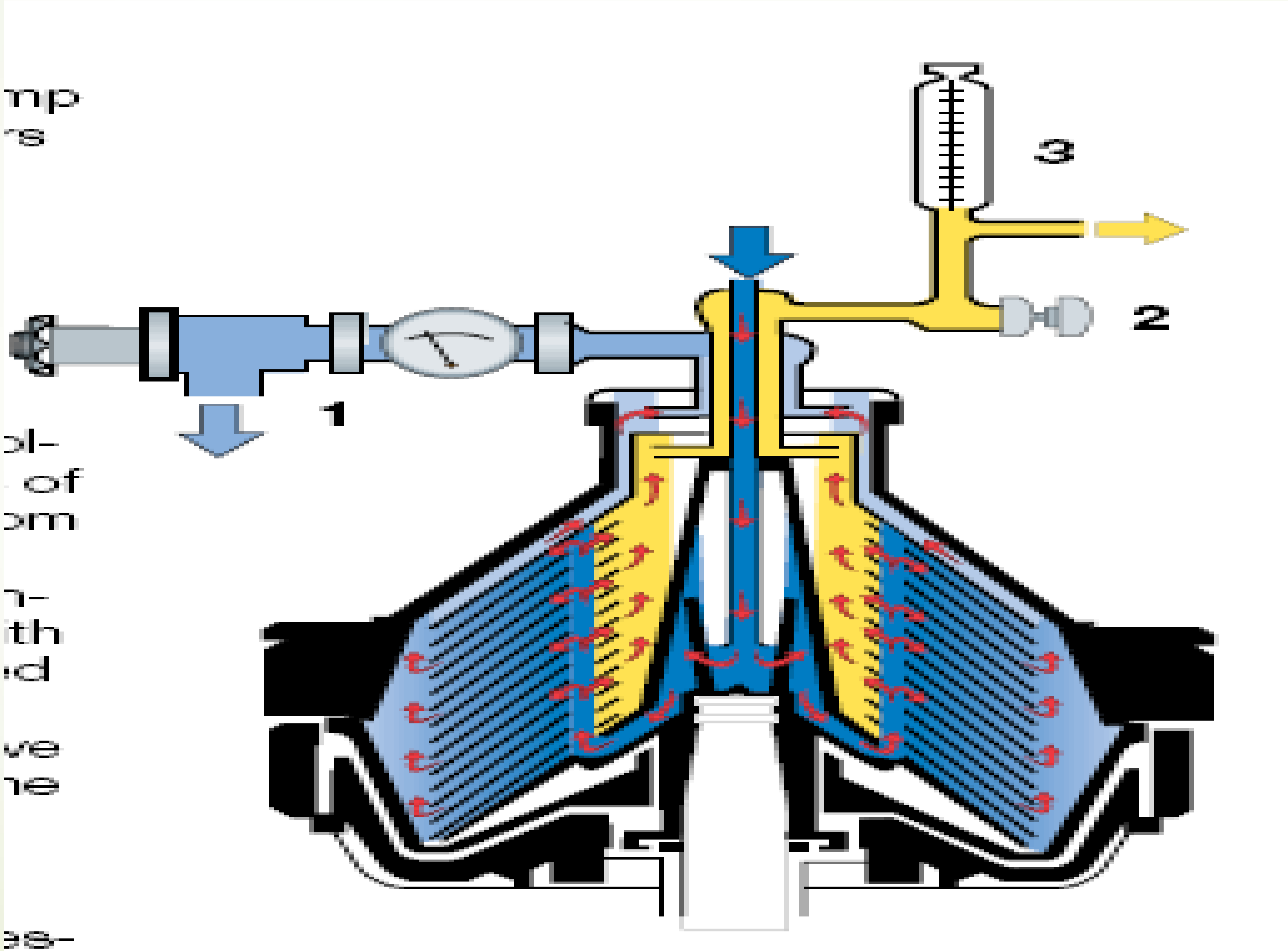


Fig. 6.2.26 Sectional view of a modern hermetic separator.

10 Frame hood
11 Sediment cyclone
12 Motor
13 Brake
14 Gear
15 Operating water system
16 Hollow bowl spindle

Control of the Fat Content in Cream



Milk Processing Technology

- Bactofugation
- Pasteurization/Sterilization
- Homogenization
- Fortification
- Bleaching
- The most important unit operations in dairy processing: Cream separator, Churner, pasteurizer, sterilizer, homogenizer, Spray dryer, Packaging, Incubation tanks with agitator and cheese processing machineries.

These clusters/agglomerates are broken up by the aseptic homogeniser located downstream.

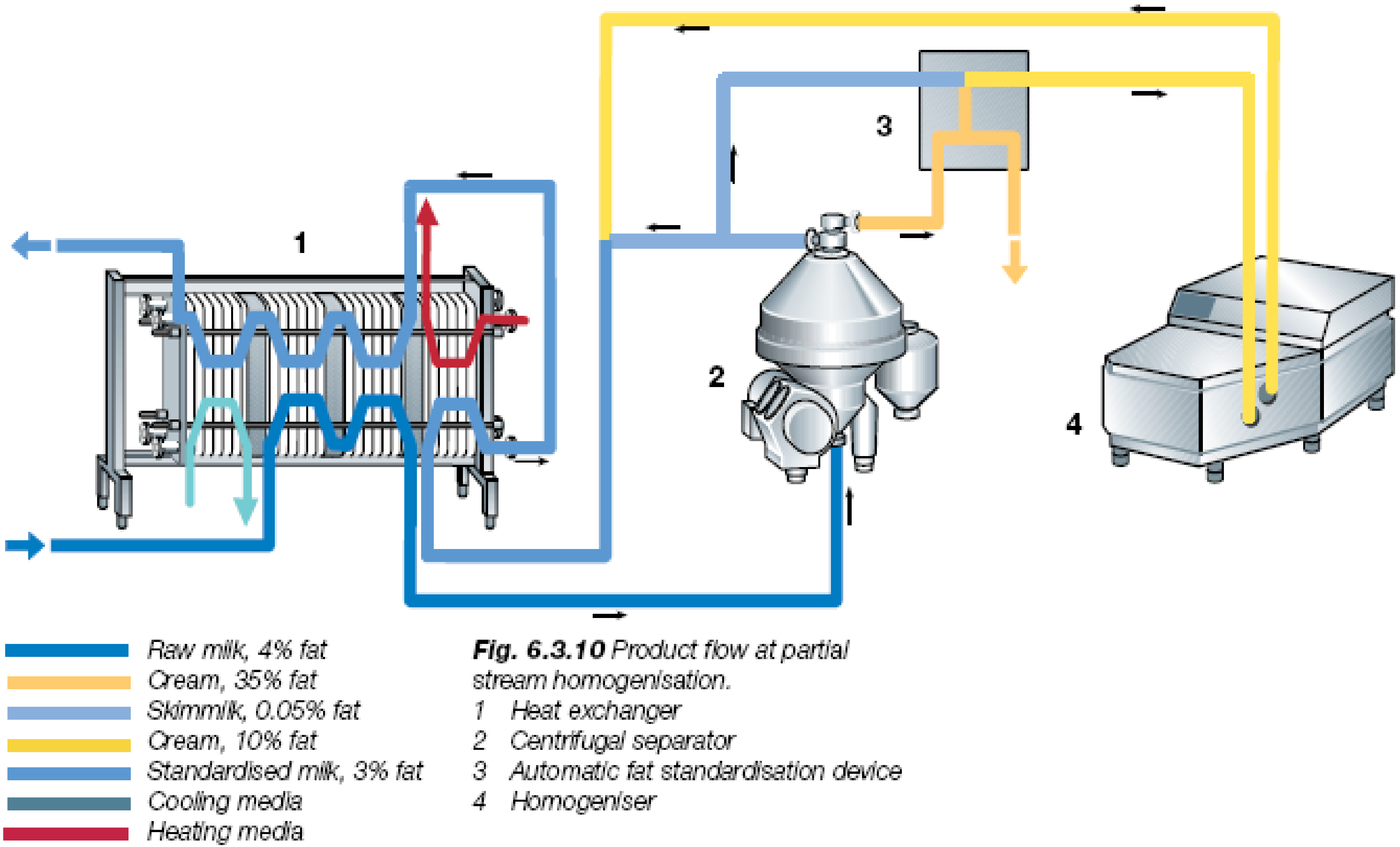


Fig. 6.3.10 *Product flow at partial stream homogenisation.*

1 Heat exchanger
2 Centrifugal separator
3 Automatic fat standardisation device
4 Homogeniser

Pasteurization

- Fluid milk is pasteurized to destroy pathogenic bacteria, yeasts and molds
- Pasteurization increases the shelf life of perishable food commodity
- Thermal processing of milk/dairy ingredients at the following times and temperatures:
  - 63°C for 30 minutes-LTLT pasteurization
  - 72°C for 15seconds-flash method; HTST pasteur.
  - 88°C for 1 second
  - **Pasteurizers: A plate type heat exchangers**

Sterilization

- 138-150^{o}C for 2 seconds-UHT processing (sterile, aseptic)

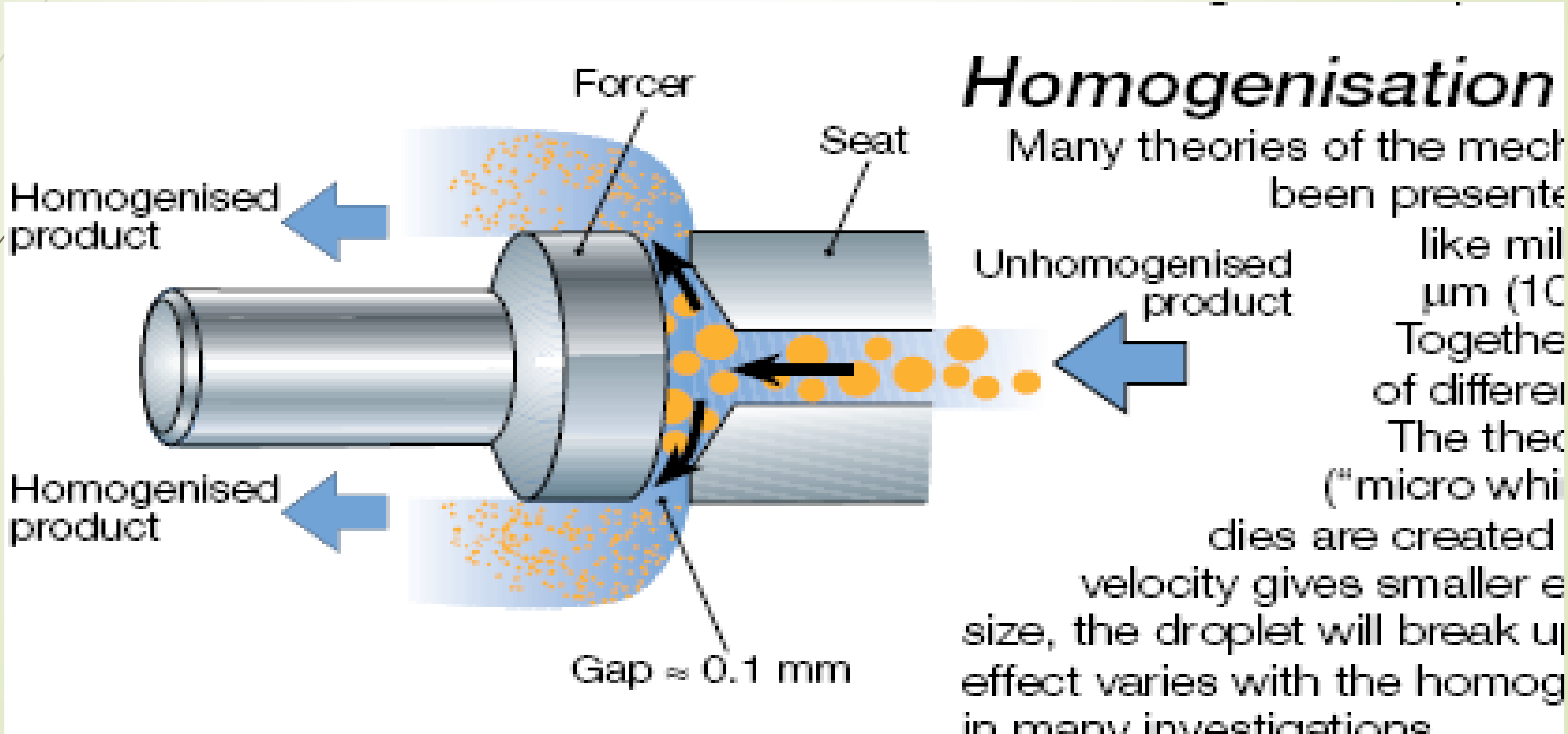
- The milk does not require refrigeration until it is opened.

Homogenizer

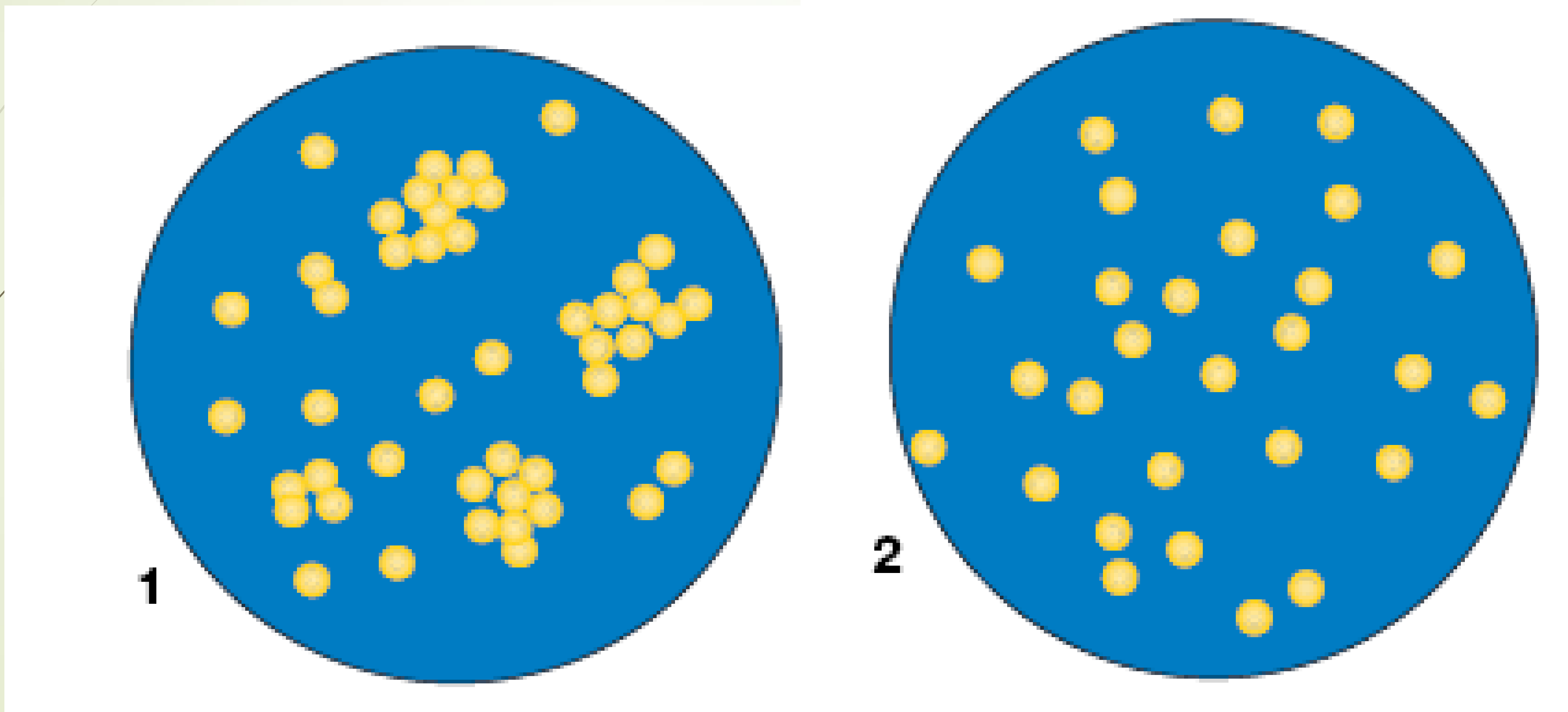
The Technology behind Disruption of Fat Globules: Homogenization

- One of the essential unit operation in dairy Industries (can reach 65 ^{0}C)
- The function of homogenization is to prevent creaming/the rising of fat to the top of the container of milk
- Expected result after homogenization: Milk maintains a more uniform composition

At homogenization the milk is forced through a narrow gap where the fat globules are split



Single-stage and *Second-stage Homogenization*



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 flavour, better mouthfeel,
- Better stability of cultured milk products.

Principles of Homogenizer

- ✓ Mechanically increases the number and reduces the size of the fat globules (from 2-6µ down to < 2 µ)
- ✓ Milk pumps under high pressure [2000-2500lbs/sq.in(psi)]

through small mesh orifices of a homogenizer

- ❖ There are single and double stage homogenizers
- ❖ The homogenization process: Emulsifies the fine fat globules

and as the surfaces of many new fat globules are formed

- ❖ Each fat globule becomes coated with a lipoprotein membrane and additional proteins from casein. These proteins adsorb to the freshly-created oil surface preventing globules from reuniting and the fat remains homogenously distributed throughout milk.
- ❖ Homogenization process prior to subsequent pasteurization

Characteristics of Homogenized Milk

- No creaming or separation of cream to the top of the containers
- More viscous and creamy milk due to a greater number of fat particles
- Decreased fat stability as fat globule membranes are broken
- Whiter milk due to a finer dispersion of fat
- More bland due to smaller fat particles

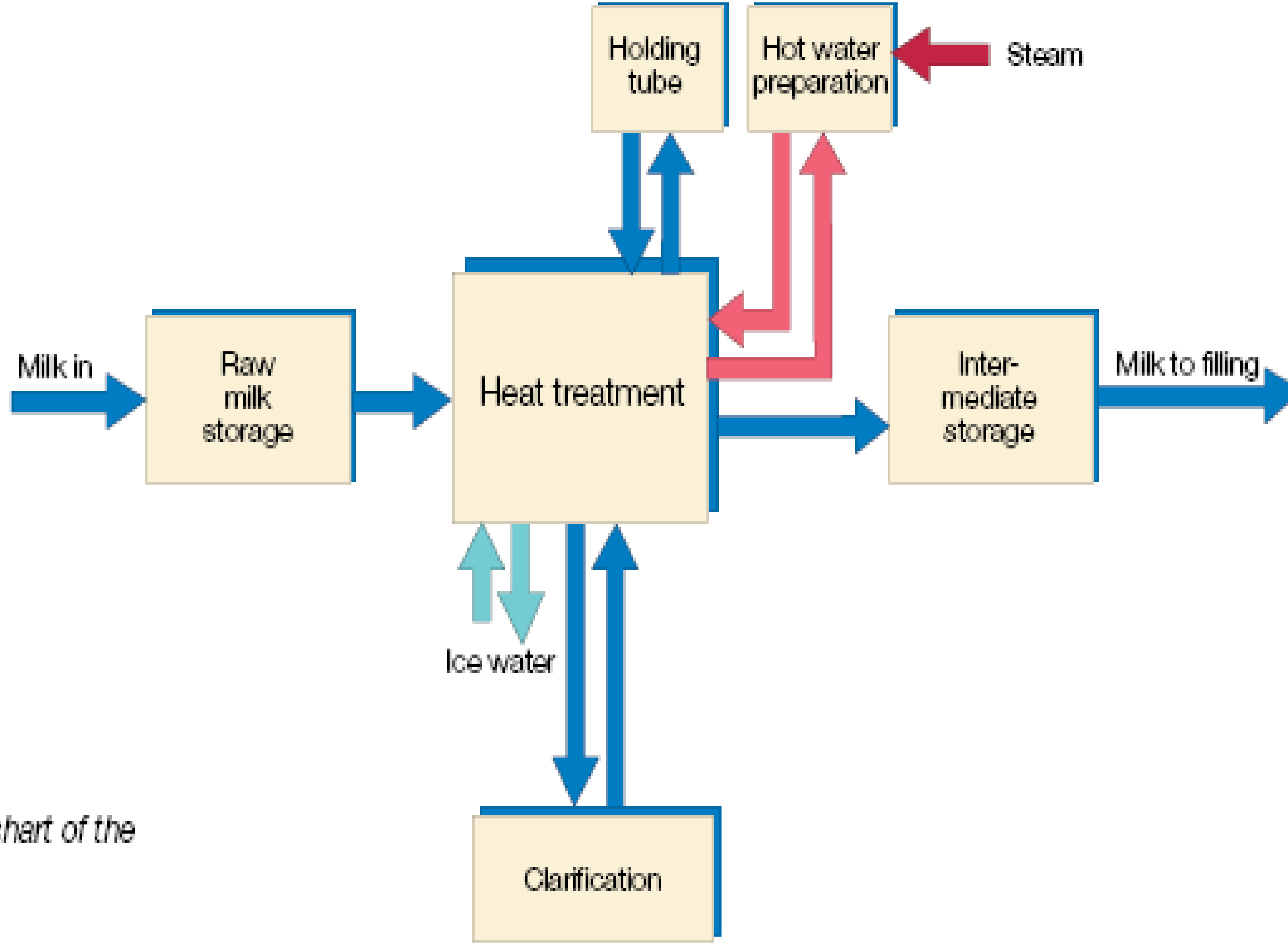


Fig. 7.1 *Generalised block chart of the milk pasteurisation process.*

The process illustrated in figure 7.1 deals with heat treatment – pasteurisation – of whole milk, e.g. market milk for sale to consumers.

Fig. 6.6.4 Flow of milk and air in the vacuum deaerator with built-in condenser.

1 Built-in condensor
2 Tangential milk inlet
3 Milk outlet with level control system

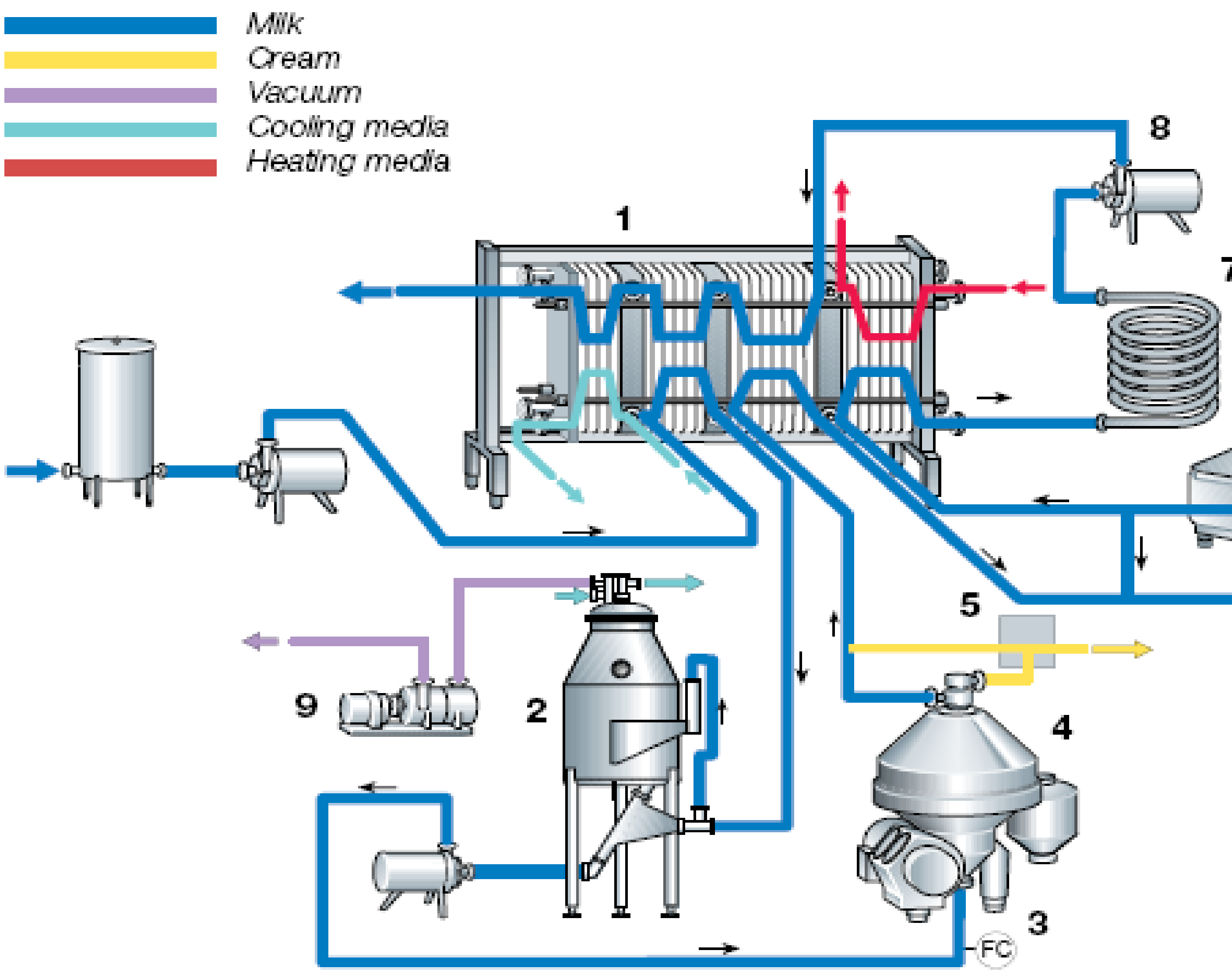


Fig. 6.6.5 Milk treatment plant with deaerator.

1 Pasteuriser
2 Deaerator
3 Flow controller
4 Separator
5 Standardisation unit
6 Homogeniser
7 Holding tube
8 Booster pump
9 Vacuum pump

***Fig. 7.5** The complete pasteuriser plant consists of:*

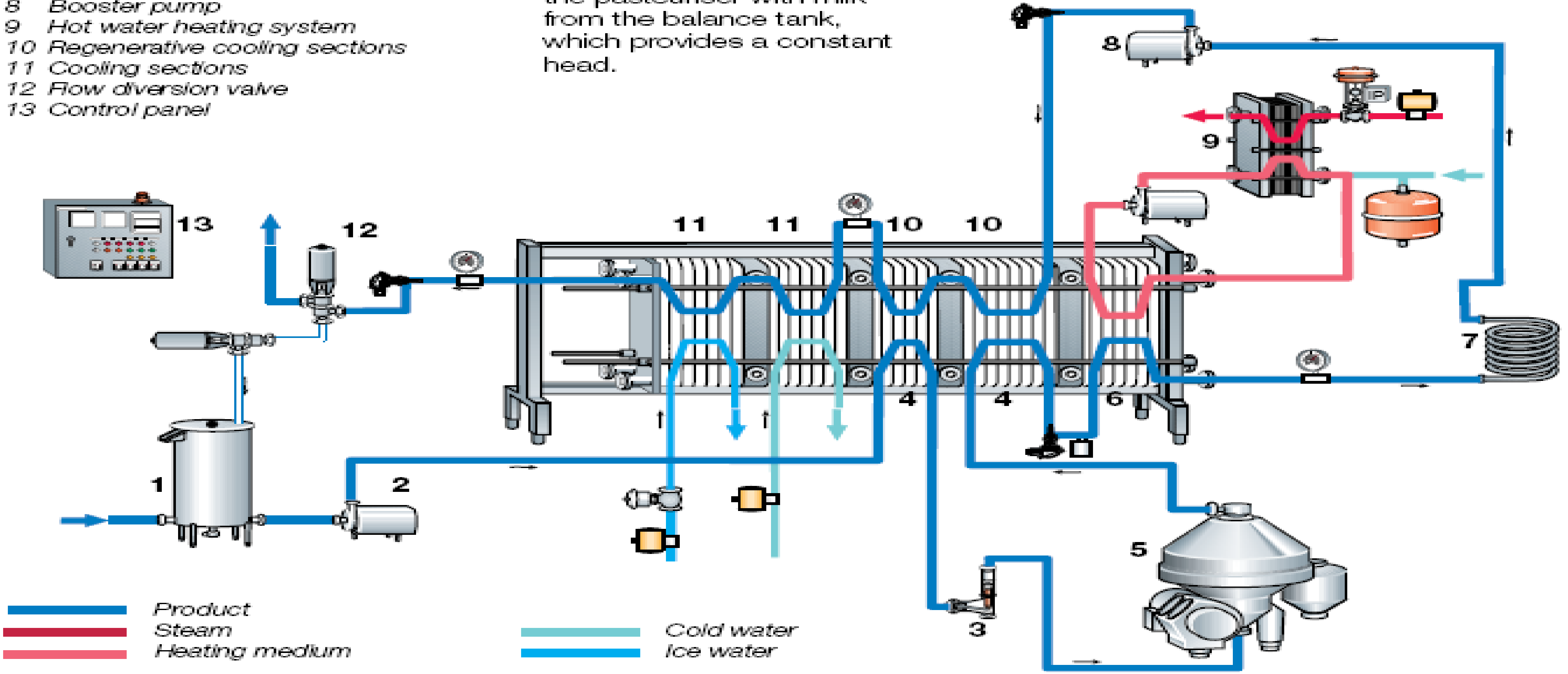
1 Balance tank
2 Feed pump
3 Flow controller
4 Regenerative preheating sections
5 Centrifugal clarifier
6 Heating section
7 Holding tube
8 Booster pump
9 Hot water heating system
10 Regenerative cooling sections
11 Cooling sections
12 Flow diversion valve
13 Control panel

with a low-level electrode which transmits a signal as soon as the level reaches the minimum point. This signal actuates the flow diversion valve, which returns the product to the balance tank.

The milk is replaced by water and the pasteuriser shuts down when circulation has continued for a certain time.

Feed pump

The feed pump supplies the pasteuriser with milk from the balance tank, which provides a constant head.



Fortification

- The addition of fat soluble Vitamin A and D to whole milk.
- Low-fat milk, nonfat milk and low-fat chocolate milk must be fortified (usually before pasteurization) with vitamins
- The expected out put of Fortification process is that: The nutritional value of the milk increased and the viscosity (MSNF) and appearance improved
- Protein fortified-need labeling

Bleaching

- Bleaching agents such as benzoyl peroxide or

its mixture with potassium alum, calcium sulfate and magnesium carbonate

- Purpose of Bleaching agents: To remove pigments such as *carotenoids* and chlorophylls
- Dosage: < 0.002% of the weight of the bleached milk
- Vitamin A is added in to milk or to the curd in the case of cheese processing

Butter and Dairy Spreads Processing Technology

Butter Categories

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.

Butter Composition

- Fat-80%
- Moisture-16%
- Salt-2%
- Milk SNF-2%

- **Butter** is an **emulsion of water in oil**, which the moisture evenly dispersed throughout.
- **In most dairying countries Legislation defines the composition of butter**.

Butter Making

- Butter- Fat concentrate which is obtained by churning cream, gathering the fat into a compact mass and then working it.
- History: The art of butter making is a long history. Old Testament
- In the past it was an article of commerce and a sign of wealth. At farm: Gravity creaming…
- At the middle of 19th : the development of centrifugal cream separator, fat test (Babcock 1890, Gerber 1892) butter churners, Refrigeration lead butter making rapidly.

Butter Making Theory

- Milk or cream is agitated vigorously at a temperature at which the milk fat is partly solid and partly liquid.
- Churning process takes place in partly filled chamber
- ✓ The resultant whipped cream occupies a larger volume than the original cream due to a large volume of air into the cream as bubbles.
- ✓ Whipped cream became coarse (semi-solid) butter granules
- ✓ Removing the buttermilk
- ✓ Kneading the butter granules into a homogenous mass
- ✓ Adjust the water and salt contents to the levels desired

Theory of the Mechanism of Churning

Fisher and Hooker’s Phase reverse Theory(1917)

Rahn’s Foam theory

King’s modern theory

- The function of air
- The difference in structure between butter and cream
- The temperature dependence of the process

Manufacture of Butter

- 1.Traditional methods of butter making
- **<u>2.Industrial manufacture of butter</u>**
- It has two-step process
- Concentrating the fat globules to fat granules and separating the granules from the other constituent of the milk or cream, namely butter milk
- Working or kneading the granules to obtain a homogeneous fatty product, the butter, by which the fat in water dispersion is reversed into a water in fat dispersion.

- Washing of cream (if poor quality)
- Pasteurization and deodorization
- Cooling (13-15 ^{0}C, tropical condition) and fermentation (ripening has two objectives: acidify the cream to solidify part of butter fat)
- Churning and working (Kneading) the butter
- Washing the butter granules and salting if needed (*)

Objectives of Fermentation/Ripening of cream in butter production

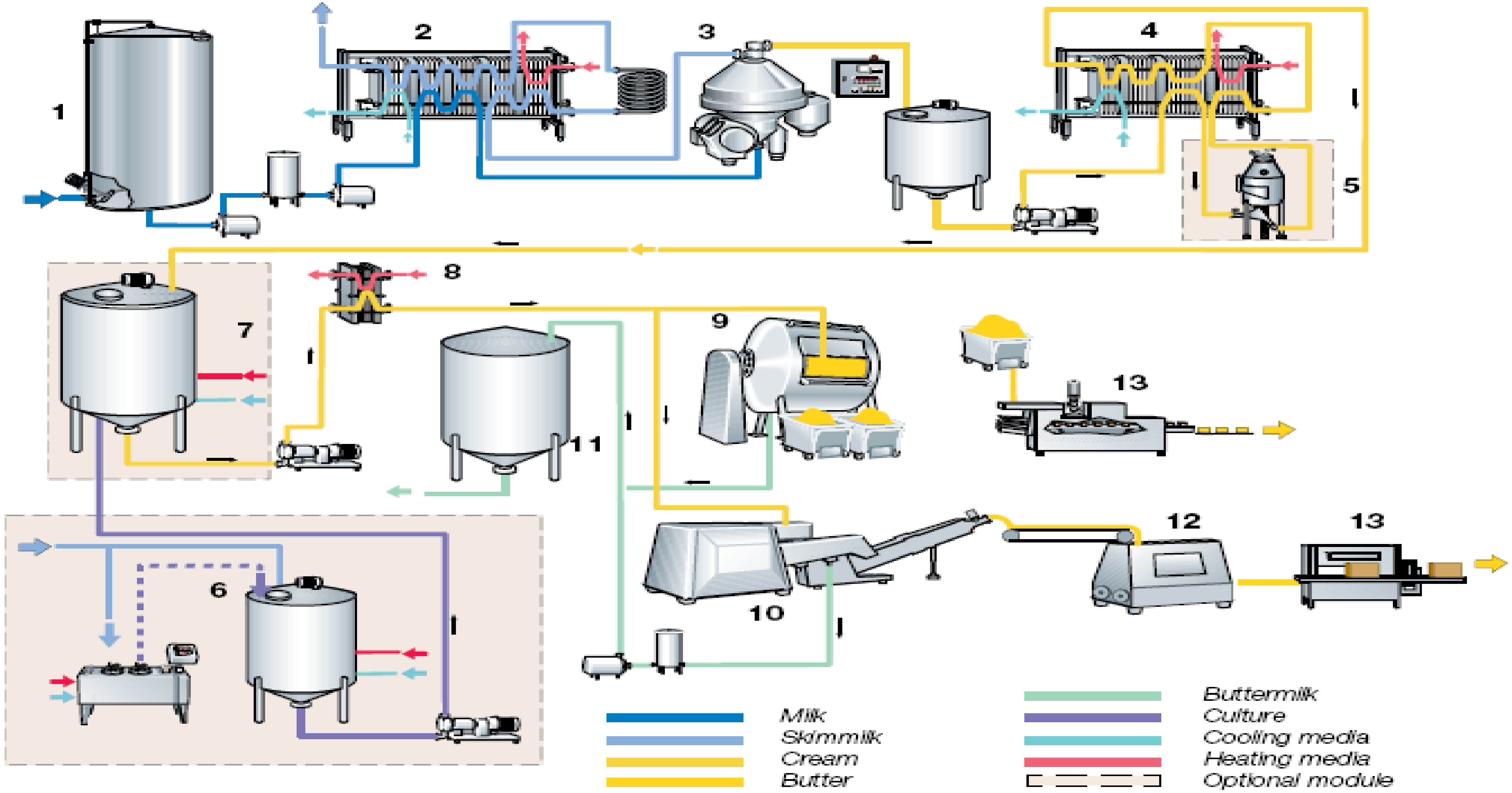
- Ripening of cream refers to the fermentation of cream with the help of desirable starter cultures
- The butter starter culture contain lactic acid producers such as *Str.lactis* and/or *Str.Cremoris*, together with aroma (diacetyl) producers (*Str.diacetilactis*) with 0.5-02.0 %, 15-16hr,15^{0}C
- To produce butter with pronounced characteristic flavor and aroma, uniformly from day to day
- To obtain exhaustive churning i.e low fat loss in butter milk due to souring/ripening

Butter Making Equipment

- Butter churner
- Butter packing machine
- Continues butter-making machines (efficient)

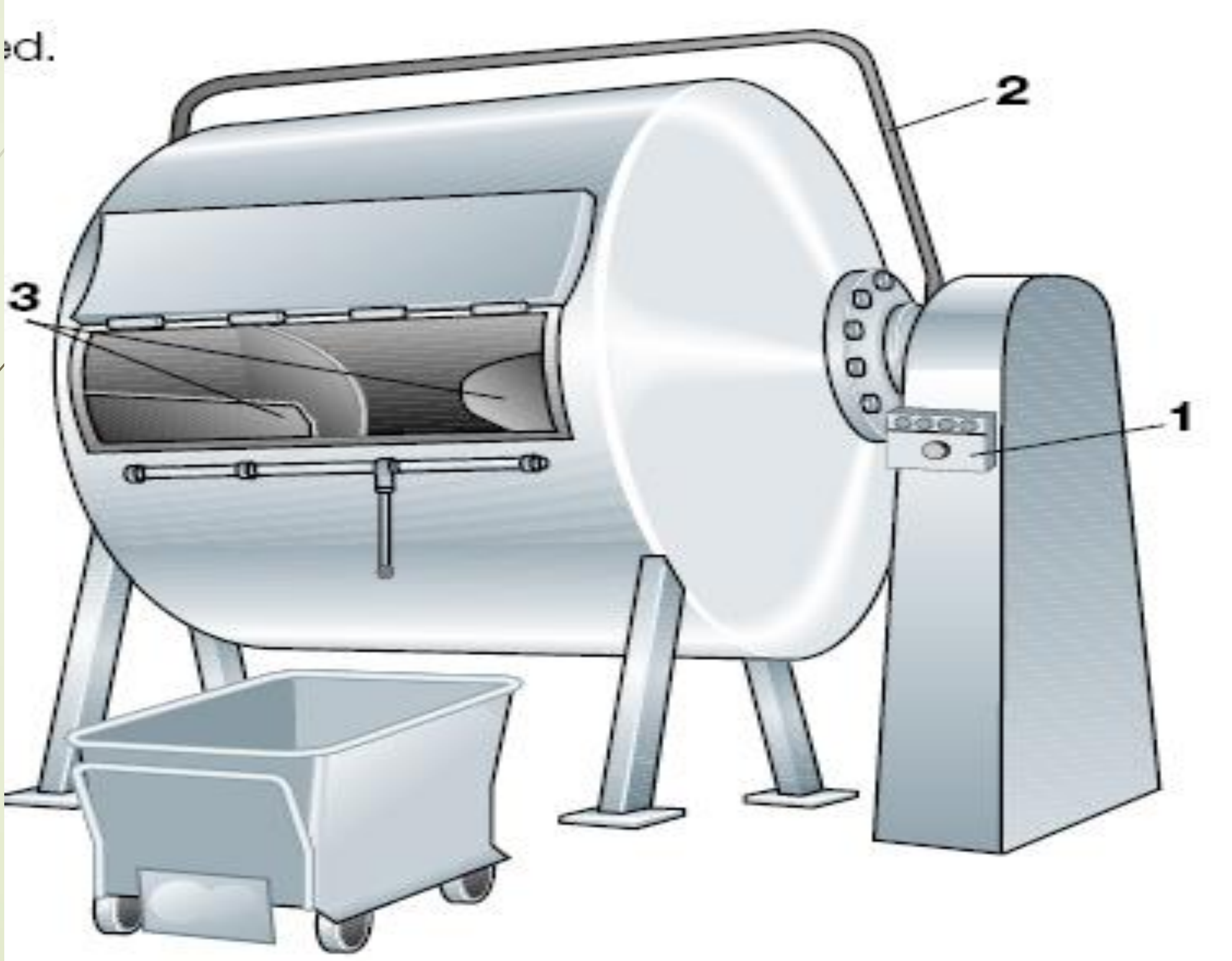
Fig. 12.2 *General process steps in batch and continuous production of cultured butter*

1. *Milk reception*
2. *Preheating and pasteurisation of skimmilk*
3. *Fat separation*
4. *Cream pasteurisation*
5. *Vacuum deaeration, when used*
6. *Culture preparation, when used*
7. *Cream ripening and souring, when used*
8. *Temperature treatment*
9. *Churning/working, batch*
10. *Churning/working, continuous*
11. *Buttermilk collection*
12. *Butter silo with screw conveyor*
13. *Packaging machines*



1
2
3
4
5
6
7
8
9
10
11
12
13
13
Milk
Skimmilk
Cream
Butter
Buttermilk
Culture
Cooling media
Heating media
Optional module

Butter Churner for Batch Production

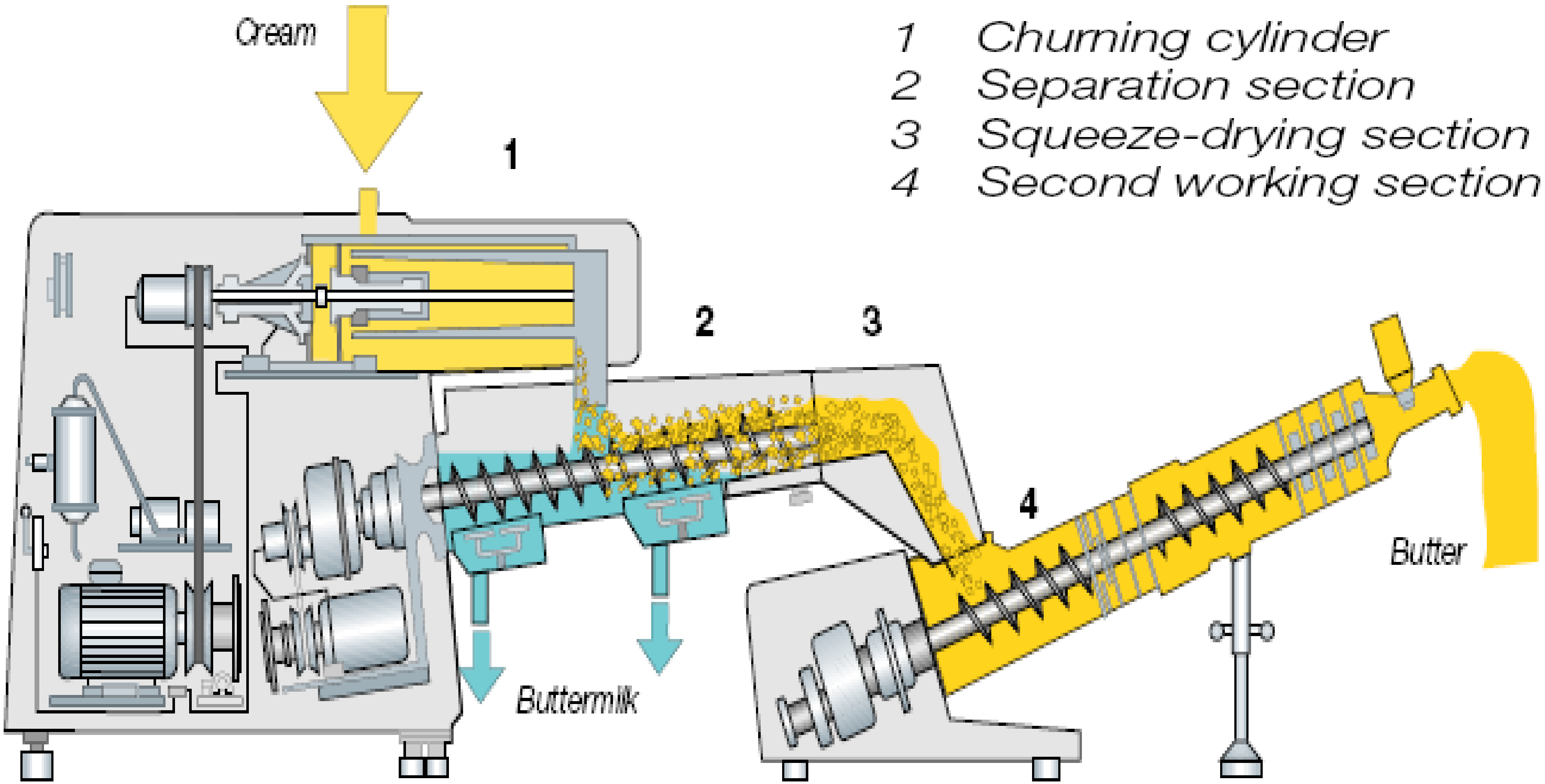


1 Control panel

2 Emergency stop

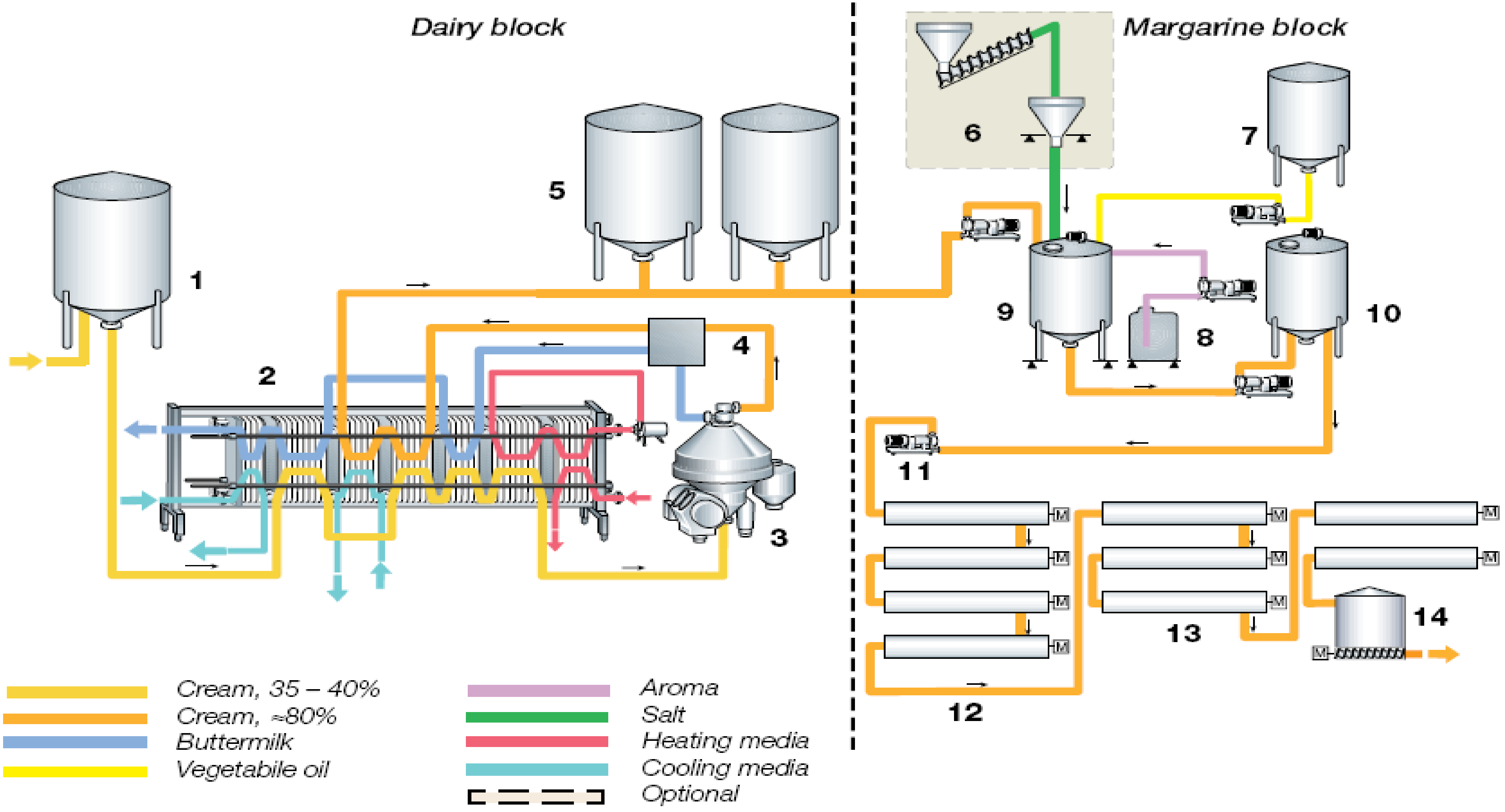
3 Angled baffles

Continuous Butter Making Machine



Churning Efficiency and Overrun**

- It is measured in terms of the time required to produce butter granules and by the loss of fat in the butter milk
- Efficiency is influenced markedly by churning temperature and the acidity of the milk or cream
- Overrun (see.pp161.) Sukumar De. (1983).


Dairy block
Margarine block
1
2
3
4
5
6
7
8
9
10
11
12
13
14
M
Cream, 35 – 40%
Cream, ≈80%
Buttermilk
Vegetabile oil
Aroma
Salt
Heating media
Cooling media
Optional

The process line

The process line is built around two blocks:

1. A typical “dairy block “with cream concentration, pasteurisation and cooling
2. A typical “margarine block” with preparation of the mix and phase inversion accompanied by working and cooling.

Fig. 12.8 The TetraBlend process line for the production of butter and dairy spreads.

Dairy block
1 Cream tank
2 Plate heat exchanger
3 Centrifugal cream concentrator
4 Cream standardisation
5 Pre-crystallisation tanks

Margarine block
6 Salt dosage, optional
7 Vegetable oil tanks
8 Aroma dosage
9 Mixing
10 Buffer tank
11 High pressure pump
12 Scraped surface cooler
13 Pin rotors
14 Silo with screw conveyor in the bottom

Quality and use of Butter

- Grading of butter
- Compositional quality (Chemical and Bacteriological)
- Organoleptic quality (consumer's reaction to its **color**, texture, **flavour** (clean)
- **Consistency, rancid flavour (X)** and keeping quality
- Packing quality and handling, storage and transportation

Defects in butter, their cause and prevention mechanisms

- ☑ Due to low quality of milk or cream
- ☑ Faulty method of manufacture and storage
- ☑ Defects such as
- ☯ Flavor (acid, bitter, cheesy, cooked, feed and weed, fishy, flat, rancid, stale…
- ☯ Body and texture: crumbly, greasy, sticky, spongy
- ☯ Color: Mottled, dull/pale, Wavy/streaky

Defects in Butter

- **Contamination by Yeast and molds**
- **Defects in flavor**
- **Storage and other sources**
- **Surface Taints (Causes: bacteria introduced by water used to wash butter during manufacture**
- **It begins on the surface of the butter and gradually penetrates to the body(Butter contains over 2% salt rarely shows this defect)**

Butter types and its products

- Whey butter from cheese factory by fat recovery using separator
- **Whipped butter**: Volume increased through the incorporation of air or inert gas such as nitrogen: used as spread of bread, hot cakes, waffles and baked potatoes
- Butter can be whipped using dough mixing machine, batch and continues ice-cream freezers, special machines
- **Butter oil**
- Dry milk fat

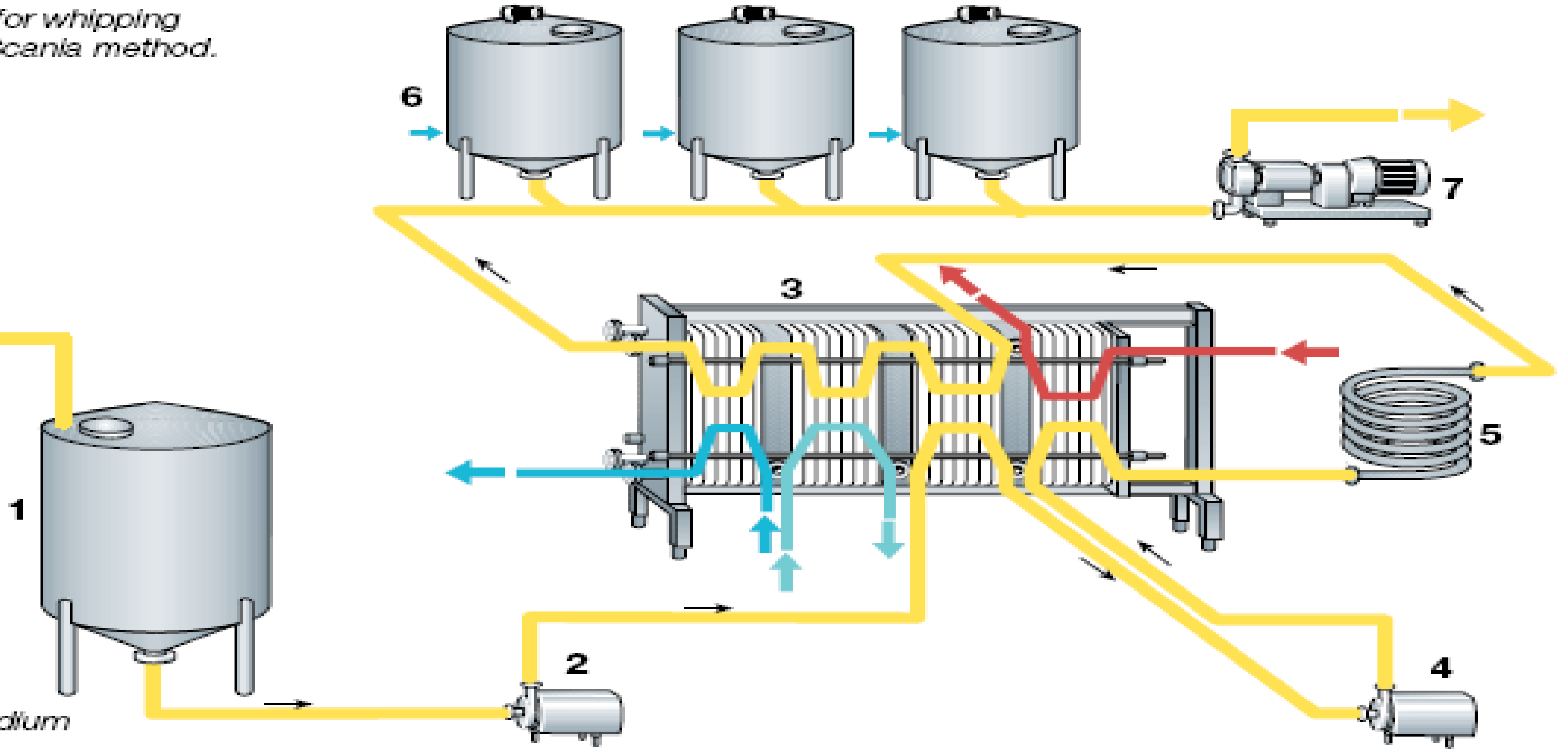
Uses of Butter

- Direct consumption with bread
- Preparation of sauce
- Cooking medium
- Baking and confectionary industries
- Manufacture of ice-cream, butter oil and Ghee

Production of Whipping Cream

Fig. 8.5 Production line for whipping cream according to the Scania method.

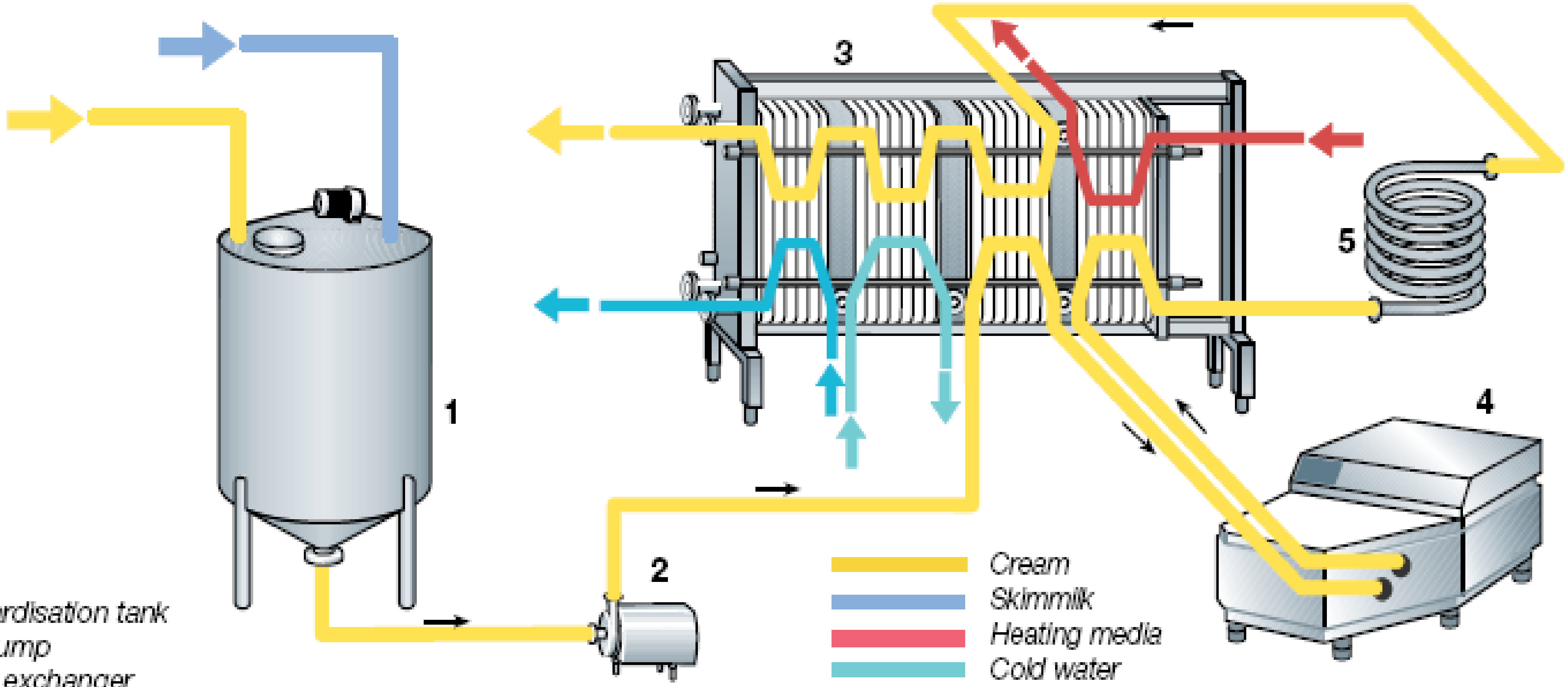
1 Holding tank
2 Product pump
3 Pasteuriser
4 Booster pump
5 Holding tube
6 Ripening tanks
7 Product pump



Cream
Heating medium
Cold water
Ice water

Figure 8.5 shows a process in which great care has been taken to eliminate rough treatment of the whipping cream. This method, developed by Alfa Laval in collaboration with some Swedish dairy co-operatives, is called

Production line for Half and Coffee Cream



1 Fat standardisation tank
2 Product pump
3 Plate heat exchanger
4 Homogeniser
5 Holding tube

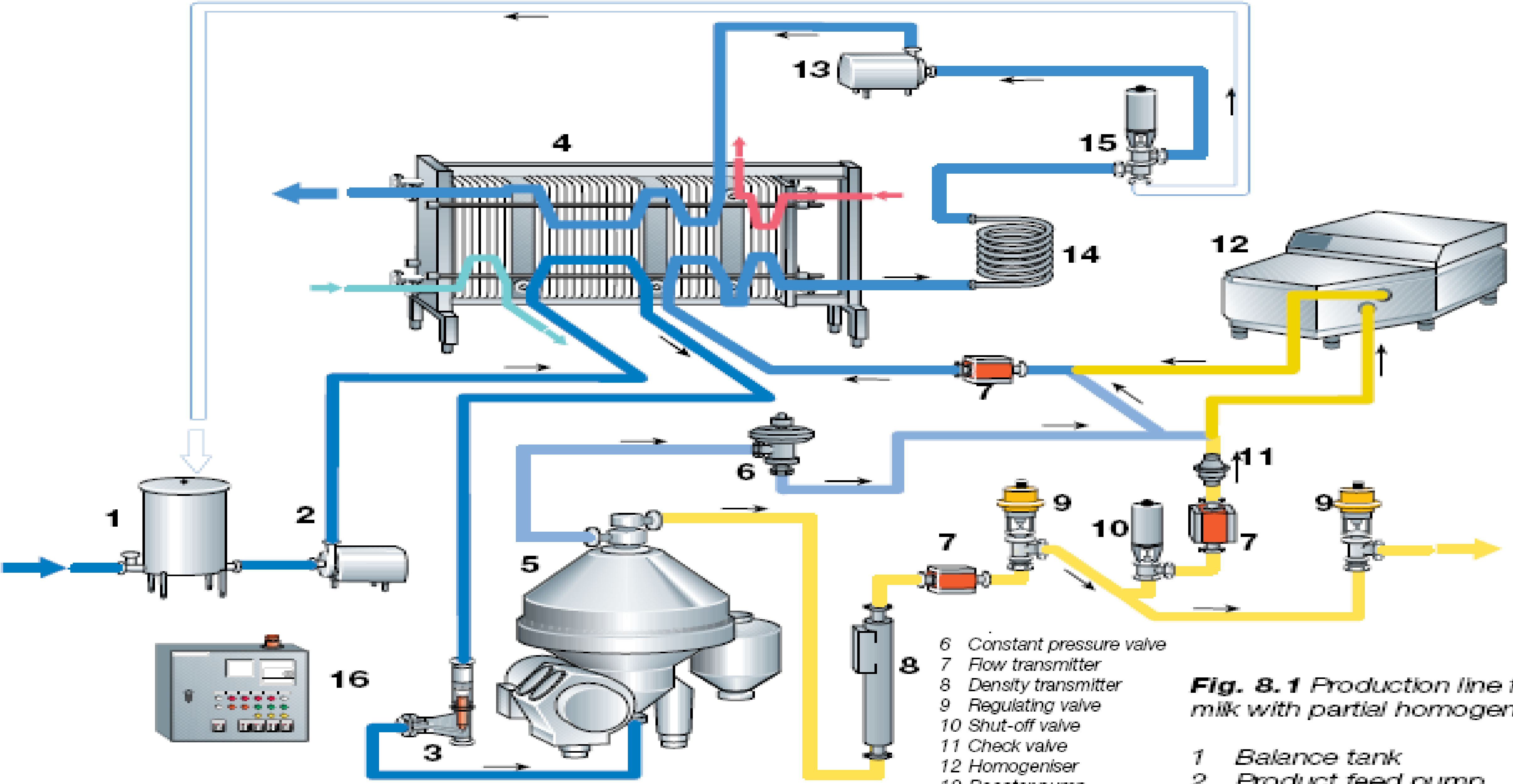


Fig. 8.1 *Production line for ma*
milk with partial homogenisation

1 Balance tank
2 Product feed pump
3 Flow controller
4 Plate heat exchanger
5 Separator
6 Constant pressure valve
7 Flow transmitter
8 Density transmitter
9 Regulating valve
10 Shut-off valve
11 Check valve
12 Homogeniser
13 Booster pump
14 Holding tube
15 Flow diversion valve
16 Process control

Pasteurization plant supplemented with Bactofugation or micro-filtration plant

plemented with a bactofugation or a microfiltration plant.

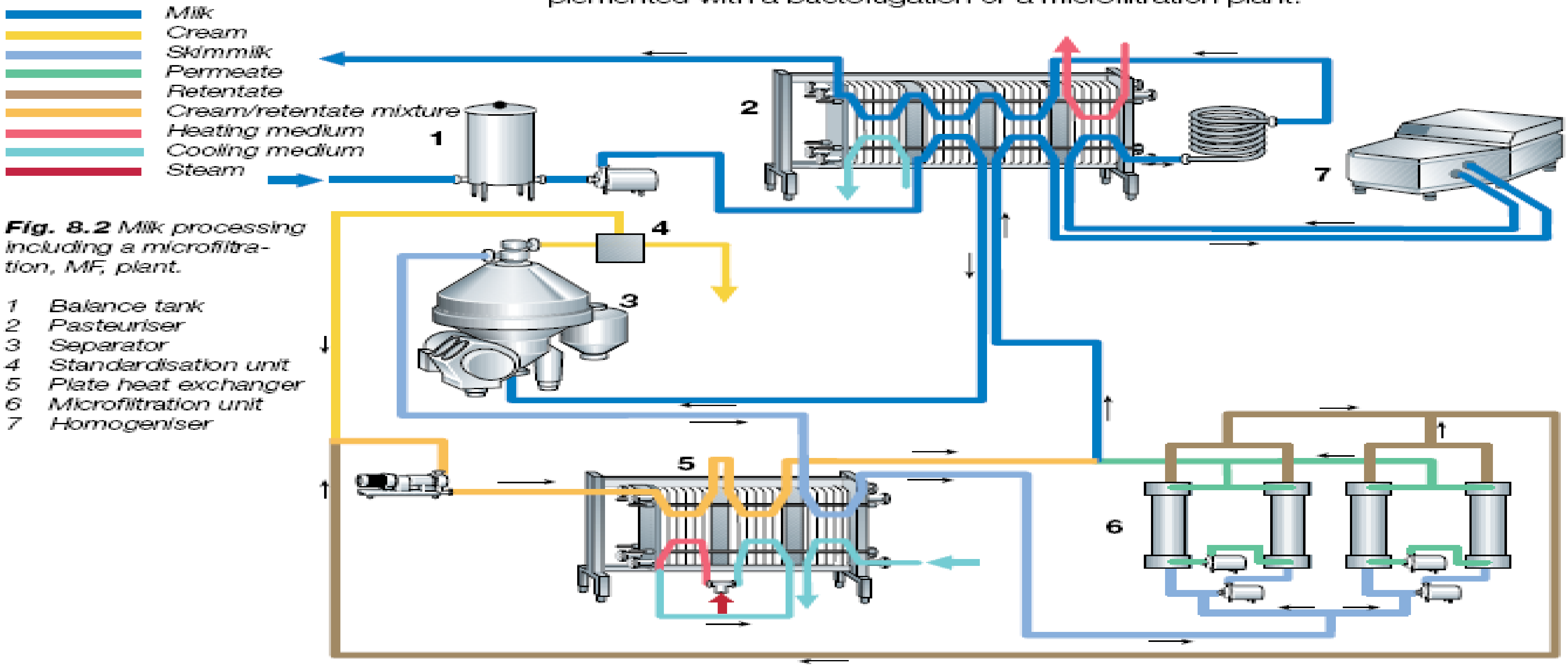
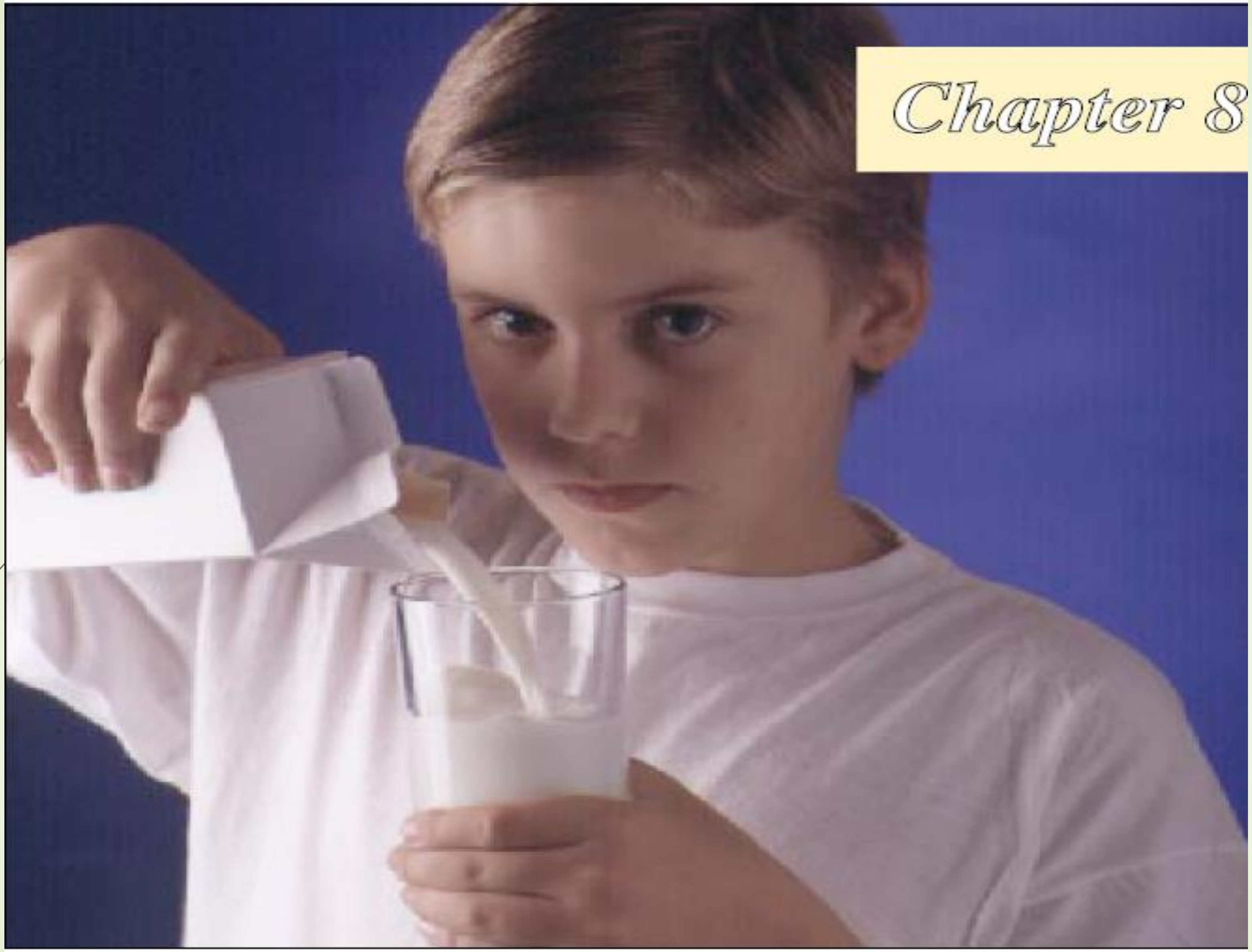


Fig. 8.2 Milk processing including a microfiltration, MF, plant.

1 Balance tank
2 Pasteuriser
3 Separator
4 Standardisation unit
5 Plate heat exchanger
6 Microfiltration unit
7 Homogeniser



Pasteurised milk products

Revision: The CRITICAL ASSET

- ✓ Self assessment and keynote preparation from various sources: Hard and soft copy

- ✓ It might reach you to the wisdom of knowledge and skill transformation

Revision: critical asset

- Revision: Leads you to perfection
- Hard work: the only green card

Hard and soft copy

- Self assessment and keynote preparation from various sources

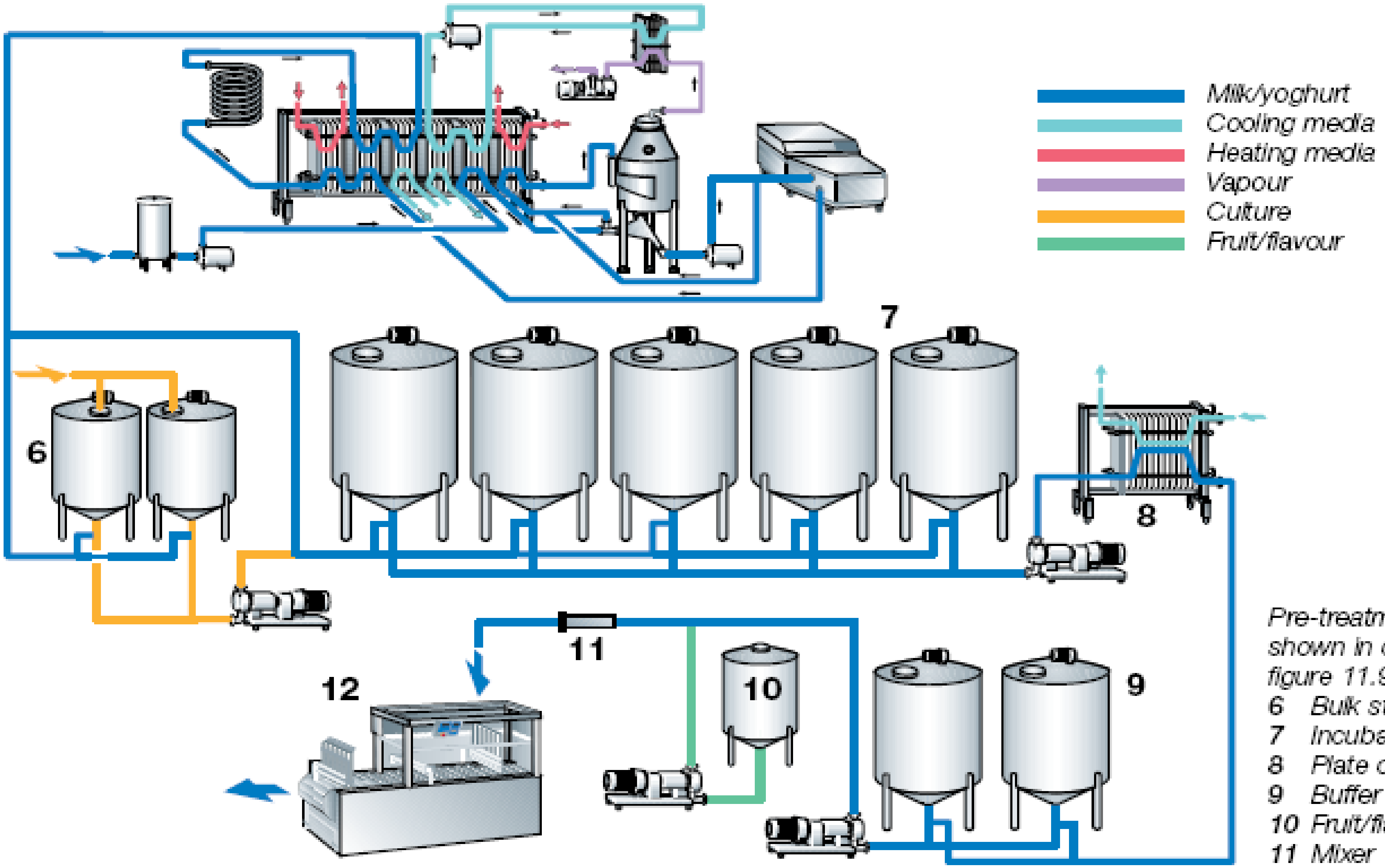
<u>Quiz</u>

- It might reach you to the wisdom of knowledge and skill transformation
- **Quiz: Check points for Chapter 1-3.**

Next… Lecture no.4

- Principles of Fermented Products Processing Technology
- Yogurt Production
- Fermented dairy Processing Technology (Kefir and Kumis)

Production line for Stirred Yoghurt



Pre-treatment is shown in detail in figure 11.9

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

Production line for the Set Yoghurt

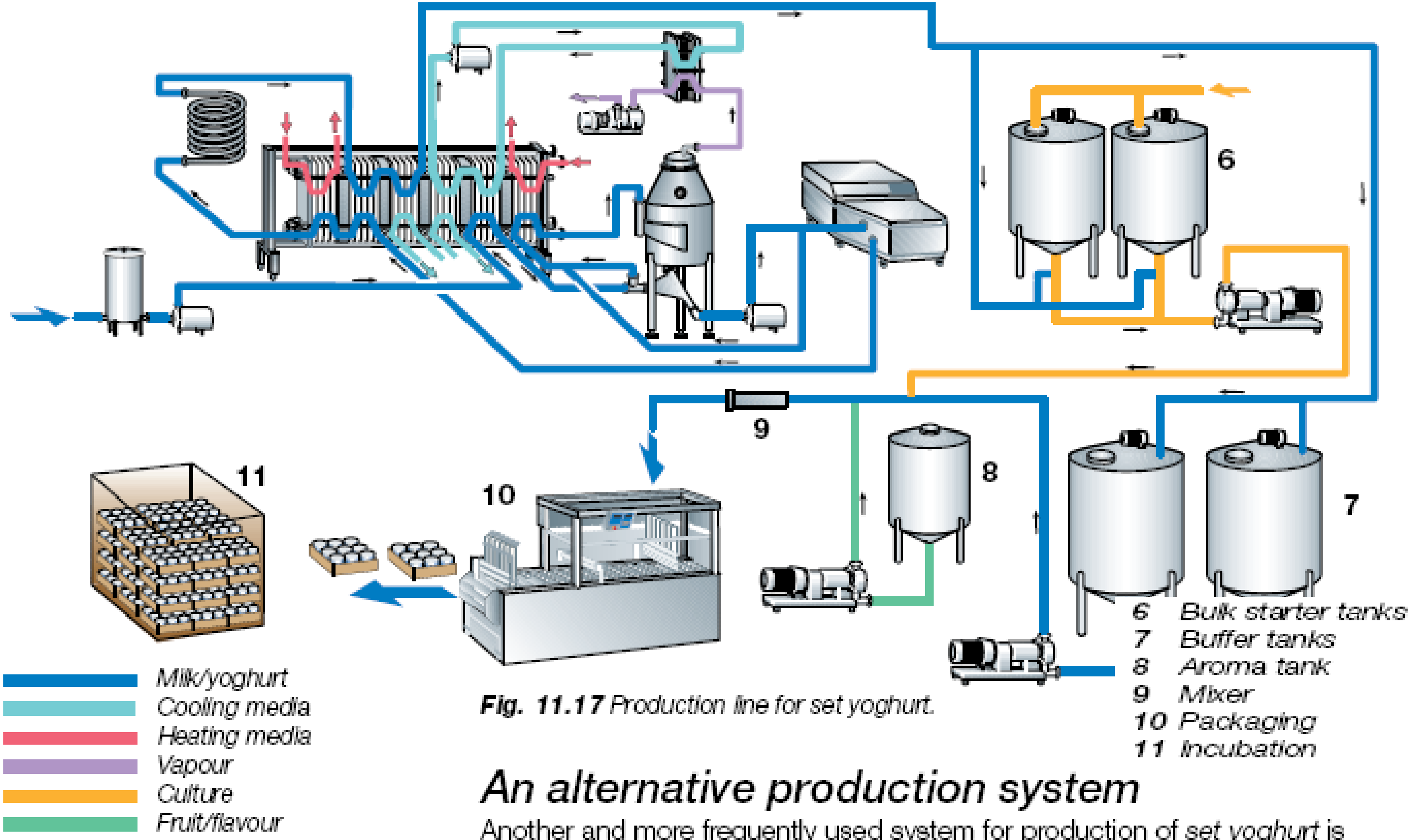


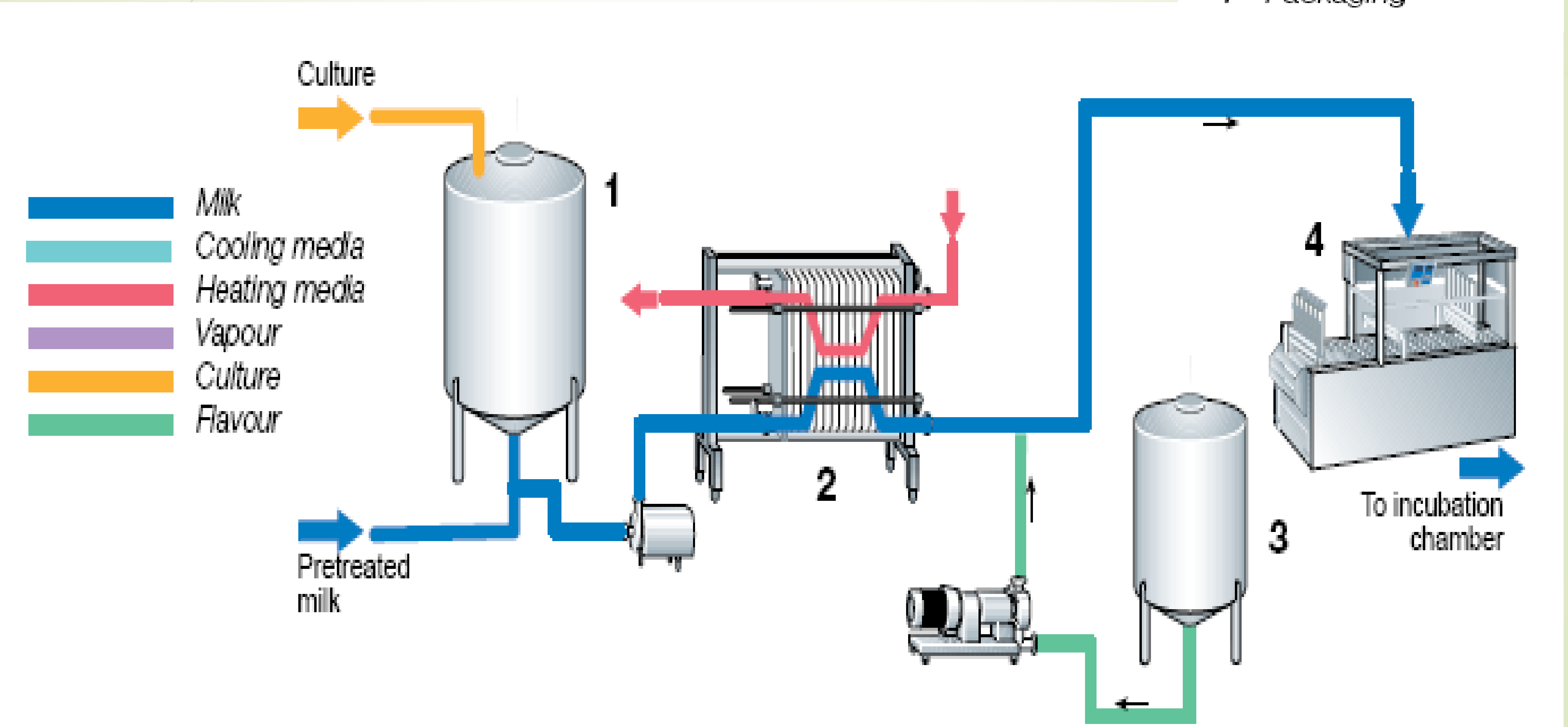
Fig. 11.17 Production line for set yoghurt.

An alternative production system

Another and more frequently used system for production of *set yoghurt* is

Final Steps in set Yoghurt Production

1 Incubation tank
2 Plate heat exchanger
3 Flavour
4 Packaging

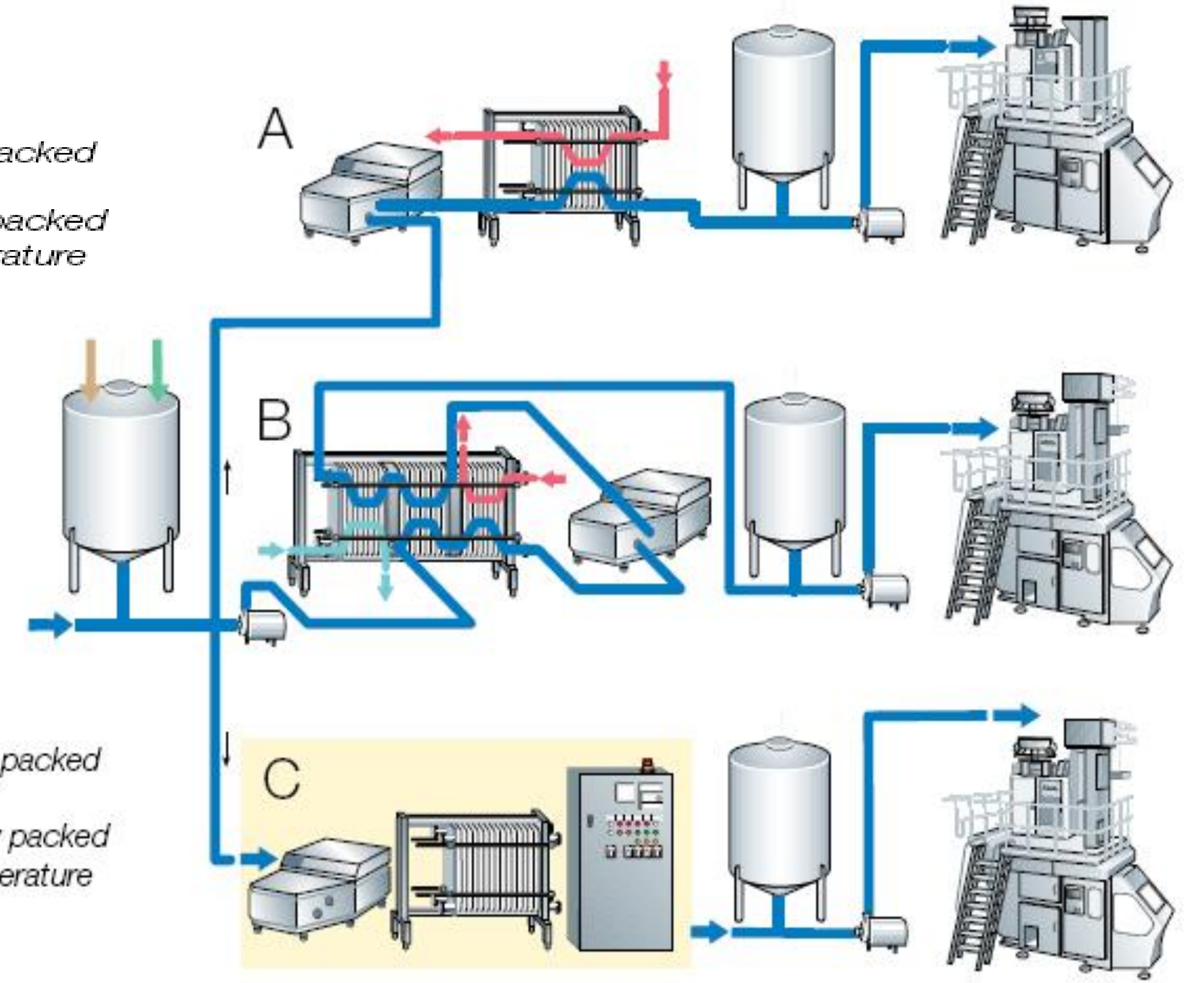


Process Alternatives for Drinking Yogurt

A *Homogenised and cooled*
Shelf life: 2 – 3 weeks, refrigerated

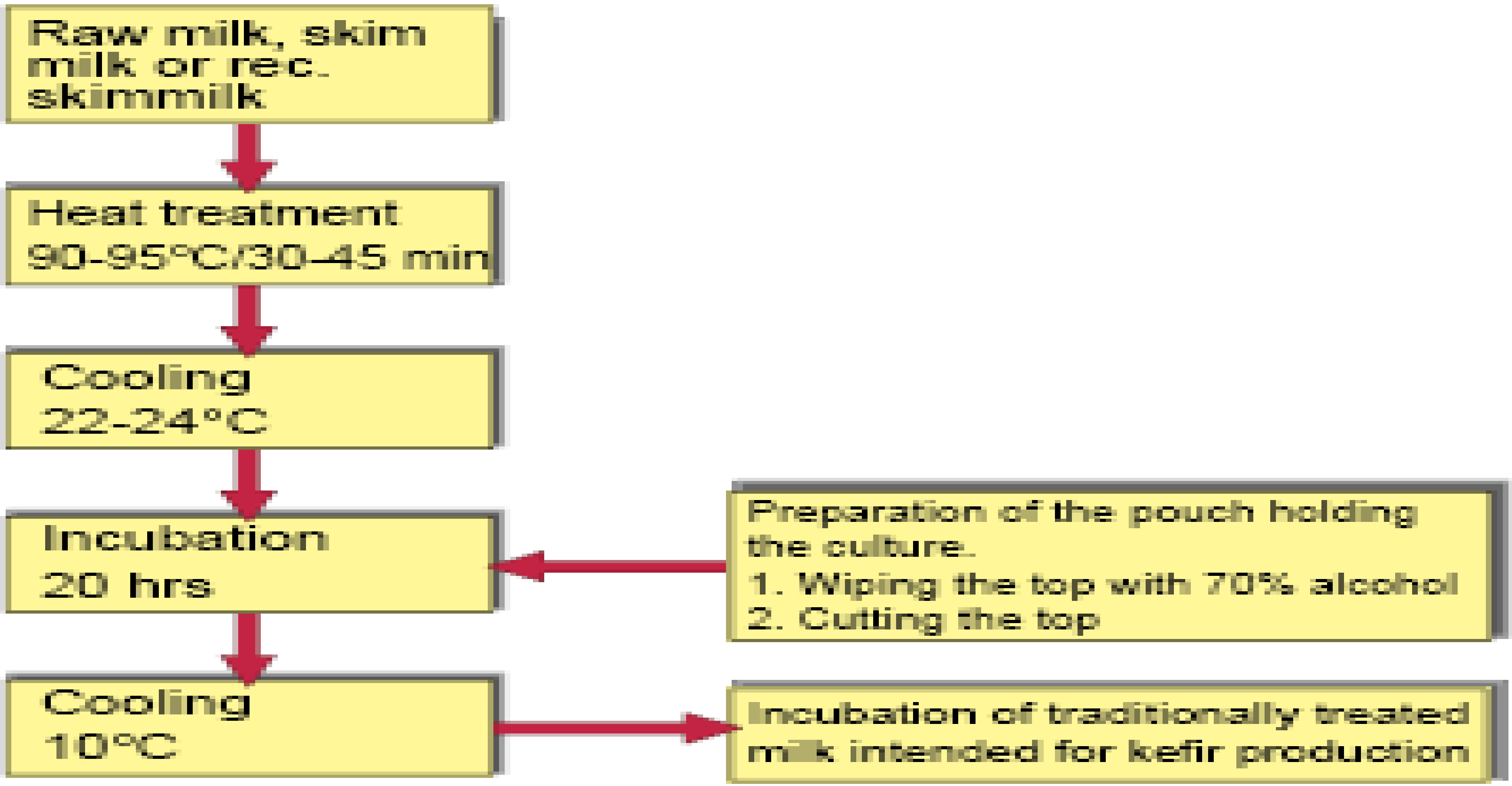
B *Homogenised, pasteurised, aseptically packed*
Shelf life: 1 – 2 months, refrigerated

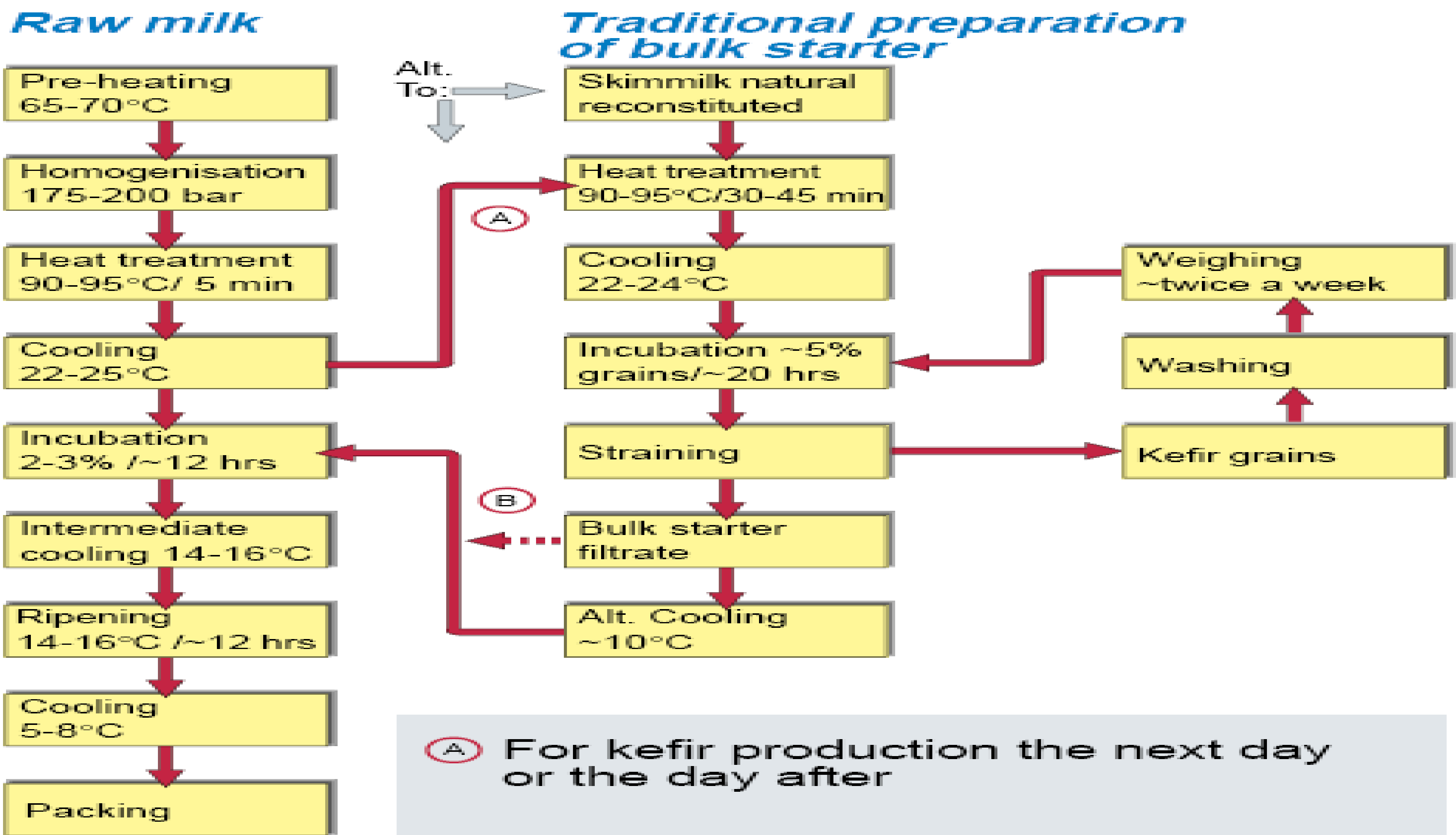
C *Homogenised, UHT treated, aseptically packed*
Shelf life: several months at room temperature



- *Yoghurt*
- *Cooling media*
- *Heating media*
- *Flavour*
- *Stabiliser*

Bulk starter preparation for kefir with a freeze-dried culture





Raw milk
Traditional preparation of bulk starter
Pre-heating 65-70°C
Homogenisation 175-200 bar
Heat treatment 90-95°C/ 5 min
Cooling 22-25°C
Incubation 2-3% /~12 hrs
Intermediate cooling 14-16°C
Ripening 14-16°C /~12 hrs
Cooling 5-8°C
Packing
Alt. To:
Skimmilk natural reconstituted
Heat treatment 90-95°C/30-45 min
Cooling 22-24°C
Incubation ~5% grains/~20 hrs
Straining
Bulk starter filtrate
Alt. Cooling ~10°C
Weighing ~twice a week
Washing
Kefir grains
A
B
A For kefir production the next day or the day after

Production of Kefir

- The Process stages are much the same as for most cultured milk products. Traditional production of

kefir:

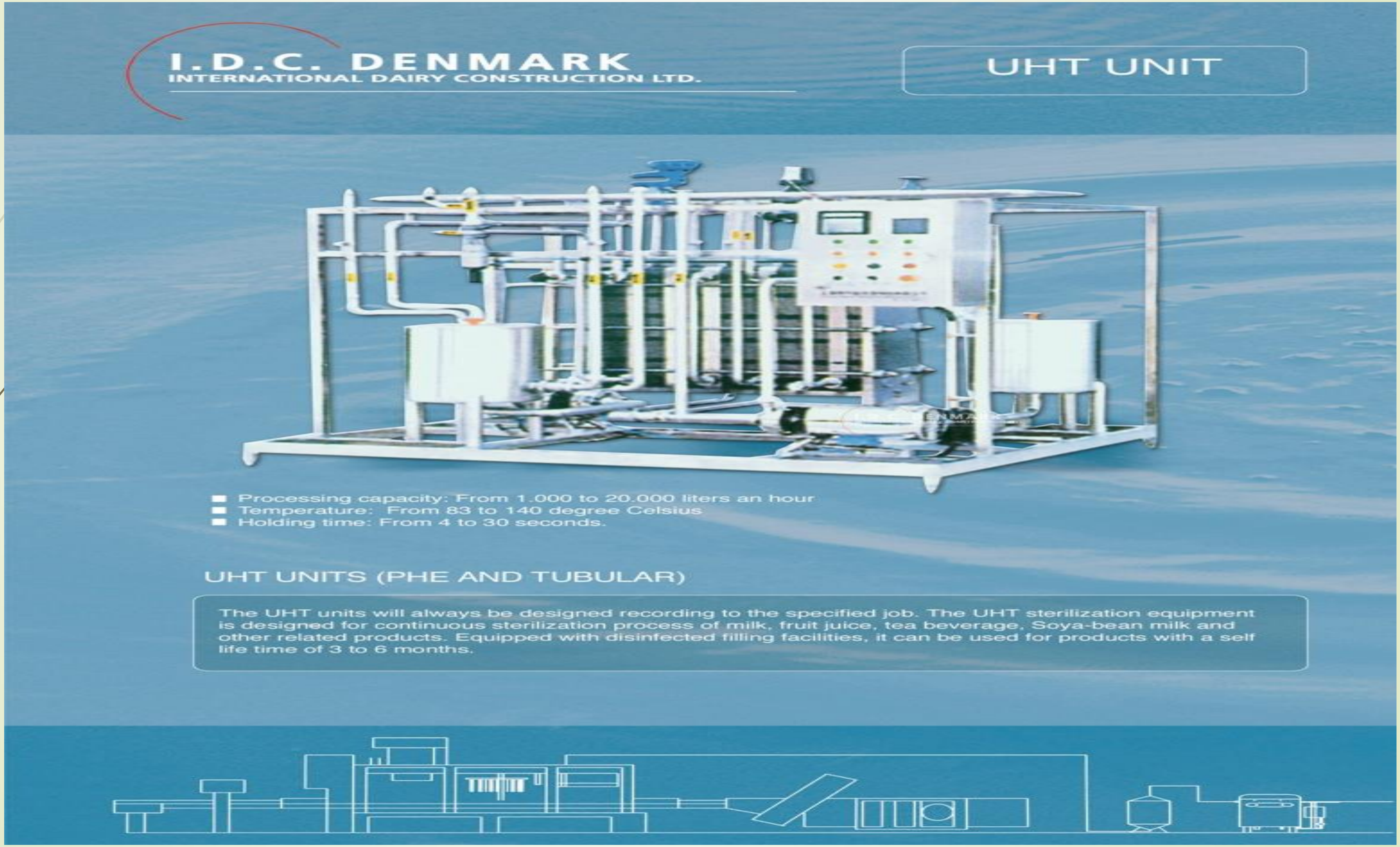
- Fat standardisation (not always practised).
- Homogenisation.
- Pasteurisation and cooling to incubation temperature.
- Inoculation with starter culture (here also called filtrate).
- Incubation in two stages (this, together with the specific culture, is characteristic of kefir).
- Cooling.
- Packing.

Dairy Plant Overview

Heat treatment and separation unit operations

Critical Unit Operations in Dairy Processing Plant

UHT Unit


I.D.C. DENMARK
INTERNATIONAL DAIRY CONSTRUCTION LTD.
UHT UNIT
Processing capacity: From 1.000 to 20.000 liters an hour
Temperature: From 83 to 140 degree Celsius
Holding time: From 4 to 30 seconds.
UHT UNITS (PHE AND TUBULAR)
The UHT units will always be designed recording to the specified job. The UHT sterilization equipment is designed for continuous sterilization process of milk, fruit juice, tea beverage, Soya-bean milk and other related products. Equipped with disinfected filling facilities, it can be used for products with a self life time of 3 to 6 months.

Long life milk

Following lecture on:

Cheese Processing Technology

THANK YOU