SCHOOL OF CHEMICAL AND BIO-ENGINEERING

ADDIS ABABA INSTITUTE OF TECHNOLOGY

ADDIS ABABA UNIVERSITY

Dairy Engineering

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Outlines

1. Principles of Dairy Food Process Design
2. Dairy Processing Unit operations

- Reception, separation and standardization of milk and cream
- Processing equipment and their working principles (Separator, Homogenizer, Pasteurizer, Heat Exchanger)

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**

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

….Covered topics

- Milk composition, factors affecting milk composition
- Chemistry of milk: Milk Chemical properties
  - 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
  - Starter culture and preparation of culture

Continued

- **International standards milk and milk products**
- ***Results of Microbial Growth in Milk (Milk spoilage indicators)***
- **Detection and Enumeration of Microorganisms**

Products of Microbial Growth

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

Dairy Engineering

- Milk Physics
- Milk Chemistry/Milk Biochemistry
- Dairy Microbiology
- Dairy Process Technology

Dairy Products Quality and Safety

Shelf life stability, Consumer satisfaction

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**

Dairy Plant: Primary operations

- Milk separation, standardization
- Working principles of Pasteurizer, Homogenizer and others
- Fluid milk and powder milk production lines and its Engineering Components

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)

Process

- Process is the **industrial operations** that modify the properties of raw materials with the purpose of obtaining products **to satisfy the needs of a society**.
- Such modifications of natural raw materials are directed to obtain products with **greater acceptance in the market**, or with **better possibilities of storage and transport**.
- **Transforming, and consuming resources available in natural surroundings.**

Dairy Food Process Design

- **Process design**: a component of Chemical Engineering and it is applied mainly in the chemical and food process industries,

- Basic part of an industrial project: Process and Plant Design
- **Engineering Design** includes Process Equipment, Process Control and Plant Utilities

SITE

Site and requirement of Milk Processing Plant.

- The plant should be located as centrally as possible within a given milk-producing area, near a source of water, or in a place where water is available.
- The transportation facility must be nearer to the plant i.e. Road, Market connectivity.
- The site should be cool and well-ventilated. It always influenced by their environment The most important factor is availability of water.
- It should be remembered that on average five liters of water are required to process one liters of milk.
- Electricity and workers availability.

CIVIL WORK AND CONSTRUCTION

- An unused building can be purchased or leased and adapted for milk processing operations. New building can be constructed. It is not uncommon to find in some remote milk-producing areas.
- The walls should be built of local stone and the inner walls lined with a lime-cement mixture for easy cleaning.
- The cement floor should have a 2 to 3 percent slope for draining water used in cleaning.
- Windows should be sufficient to provide adequate ventilation.
- Building size will of course depend on the quantity of milk received during the peak production period. An average quantity of milk which can be processed by a small-scale unit amounts to 100 to 500 liters per day.

PLANT SET UP

- Plant set up. When civil work completed equipment are ready to install.
- The equipment needed to run the dairy processing plant depends on several factors.
  How much milk is to be collected ?
  How far and how scattered are the milk producers ?
  What kind of product is to be produced ?
- In the standard milk processing pattern, commencing with milk collection and ending with the sale of the dairy products.

OPERATIONS AND PRODUCTION

- Heat treatment: Pathogenic germs in milk are destroyed by heating the milk to a minimum temperature of 63°C for 30 minutes.
- Inoculation: Due to heat treatment, which destroys a large number of lactic bacteria, cheese or yoghurt-making requires the addition of lactic bacteria to the milk. These bacteria are selected according to the type of finished product required.
- Clotting: Milk changes from a liquid to a solid state through the use of a coagulant: rennet.
- Curd-Separation: In cheese-making, the milk after coagulation is cut and separated into a liquid whey, and cheese curd.
- Ripening: This phase of cheese-making allows cheese texture to become homogeneous and the aroma to develop.

OPERATIONS AND PRODUCTION

- Churning: In this operation, cream is churned to produce a semi-solid product which becomes butter.
- Melting and emulsification: Defective cheeses are melted and emulsified with salts to obtain a solid consistency and, after cooling forms processed cheese.

PROCESSING

- Reception: the following equipment is needed for the reception of milk brought in by producers themselves and by the collector: a milk scale and a pail.
- Storage: a milk funnel and 50 liter milk cans.
- Standardization/Cream separation: a manual cream separator has to be used to skim a portion of the milk received.
- Heat treatment: there are several possibilities for heat treatment, depending on the available power source. Under the least favorable circumstances, the sole available energy source is wood or peat. The best thing to use in this case is a "boiler/water bath"
- Cooling: the milk is cooled with the help of milk chillers.

PROCESSING

- Clotting: The cheese vat can be of aluminum with a tap for draining the whey

- Pressing: different kinds of cheese (curd) presses can be made. The simplest press is made by placing weights or cement block on the molded cheese (curd) as shown in the following diagram:

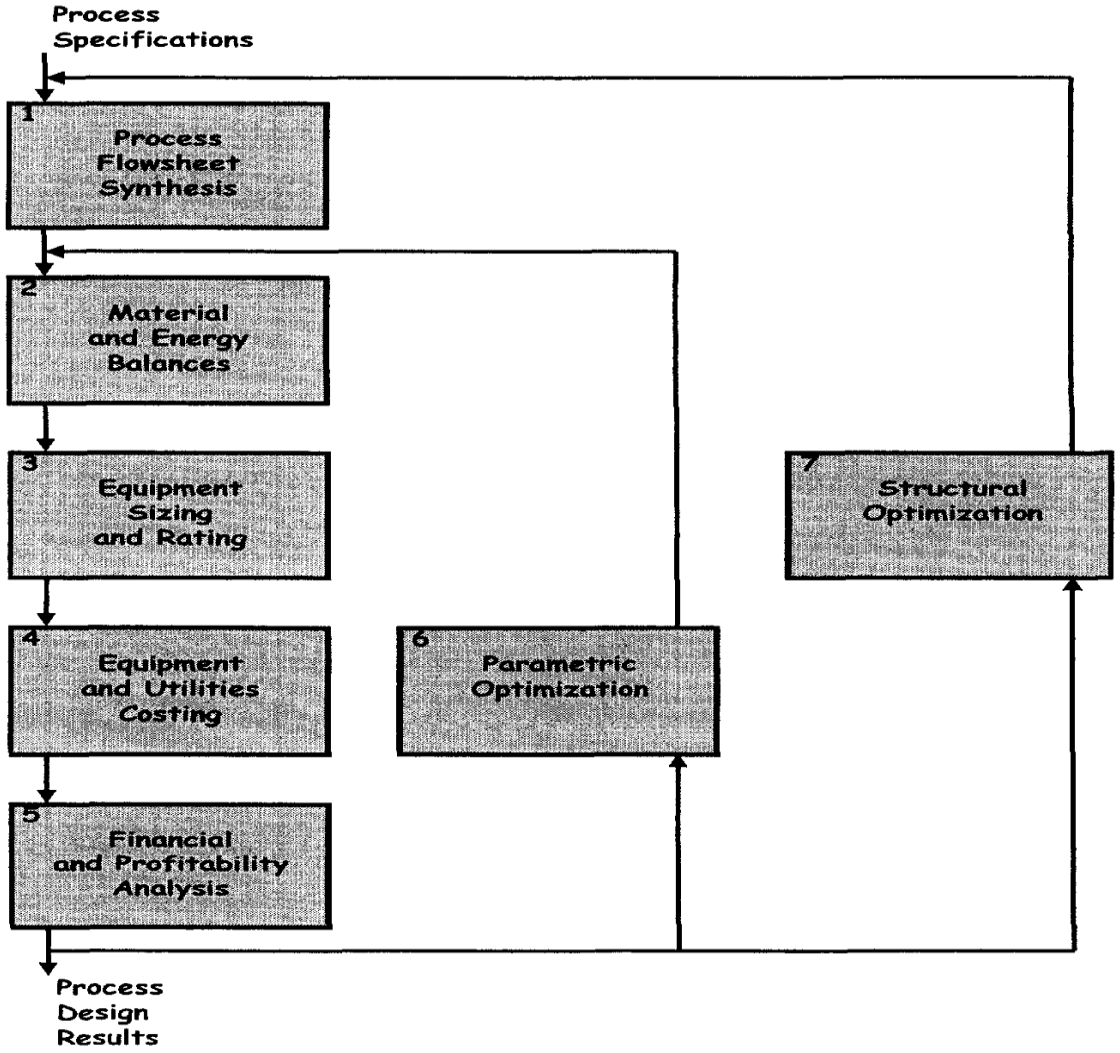
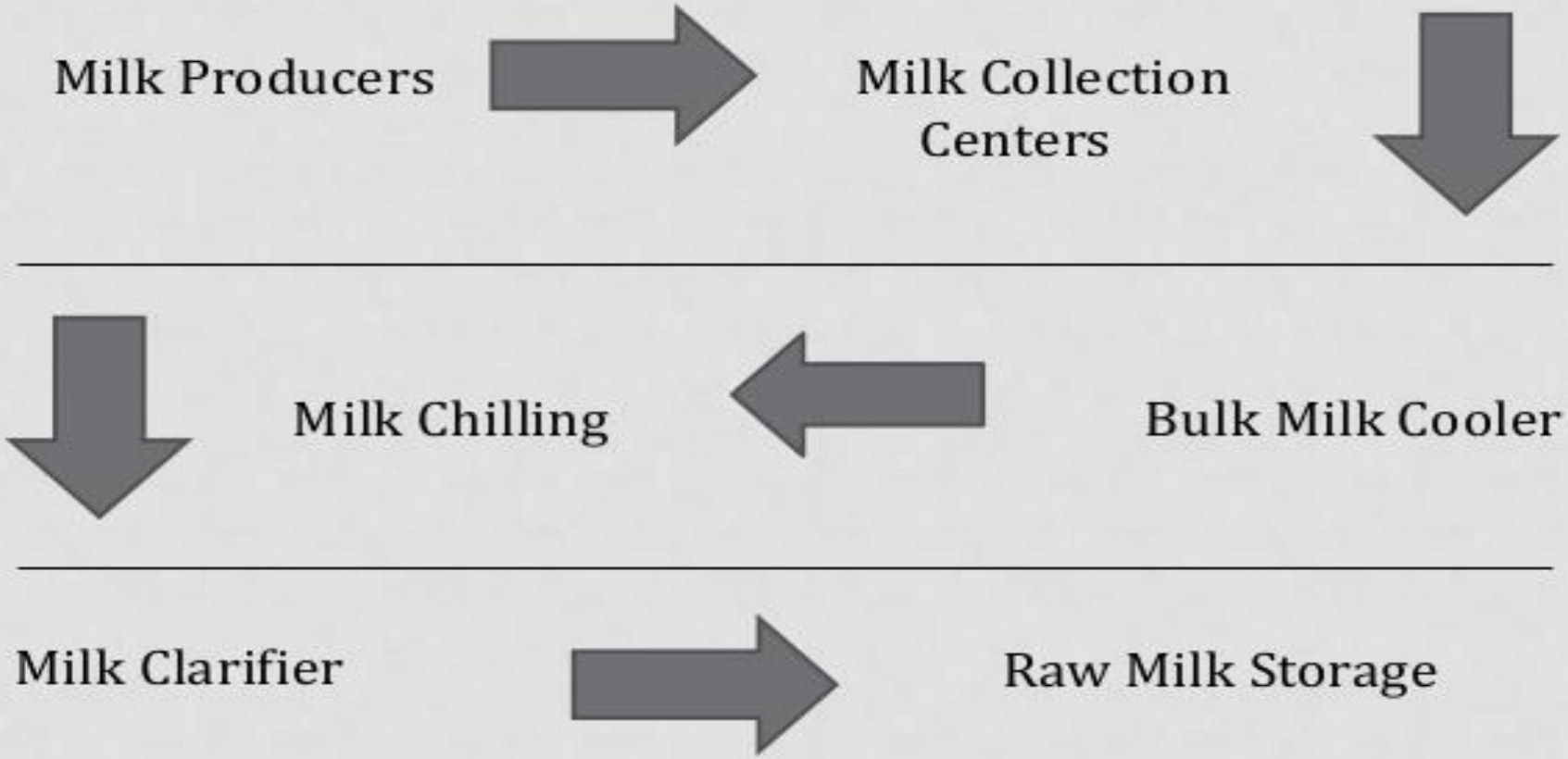


Figure 2.1 Information flow diagram of process design.

PROCESSING


Milk Producers
Milk Collection Centers
Milk Chilling
Bulk Milk Cooler
Milk Clarifier
Raw Milk Storage

Dairy Process Engineering

- **Dairy Process Engineering** can also be defined as "the science and technology of conceiving, calculating, designing, building, and running the facilities where the **transformation processes of agricultural products**, at the industrial level and as economically as possible, are carried out."
- The transformation processes of agricultural raw materials into final products, or on conservation of materials and products.

Dairy Engineering: Concepts

- **Dairy engineer** in the dairy industry should know the basic **principles of process engineering** and be able to develop new production techniques for agricultural products.
- He/She should also be capable of designing the equipment to be used in a given process.
- **Transformation and Commercialization of Agricultural Products**
- **Leadership quality and business oriented**

Dairy food process engineering

- The main objective is to study the principles and laws governing the
- Physical,
- Chemical, or
- Biochemical stages of different processes, and the apparatus or equipment by which such stages are industrially carried out.
- **Physical, chemical, and biochemical: Unit operations based on the nature of transformation**

Process Block Diagram

- **Dairy processes** are usually schematized by means of flow charts to synchronize the process.

- These are diagrams of all processes that indicate different manufacturing steps, as well as the **flow of materials and energy in the process**.

Unit operations

- **Physical stages**: grinding, sieving, mixture, fluidization, sedimentation, flotation, filtration, rectification, absorption, extraction, adsorption, heat exchange, evaporation, drying, etc.
- **Chemical stages**: refining, chemical peeling
- **Biochemical stages**: fermentation, sterilization, pasteurization, enzymatic peeling
- All stages that take place in the **transformation processes of agricultural products** constitute the so-called **Unit Operations of the Dairy food industry**.

Unit operations

- Unit operations can be classified into different groups depending on the transferred property, since the possible changes that a body may undergo are defined by variations in either its mass, energy, or velocity.

- Thus, unit operations are classified under mass transfer, heat transfer, or momentum transfer.

Table 2.2 Classification of Unit Operations of Food Processing

Group of Operations	Typical Food Processing Operations
Mechanical Transport	Pumping of Fluids Pneumatic Conveying Hydraulic Conveying Mechanical Conveying
Mechanical Processing	Peeling, Cutting, Slicing Size Reduction Sorting, Grading Mixing, Emulsification Agglomeration Extrusion, Forming
Mechanical Separations	Screening Cleaning, Washing Filtration Mechanical Expression Centrifugation
Heat Transfer Operations	Heating, Blanching Cooking, Frying Pasteurization Sterilization Evaporation Cooling, Freezing, Thawing
Mass Transfer Operations	Drying Extraction, Distillation Absorption, Adsorption Crystallization from Solution Ion Exchange
Membrane Separations	Ultrafiltration Reverse Osmosis
Non-Thermal Preservation	Irradiation High Pressure Pulsed Electric Fields
Packaging	Filling, Closing Metallic, Plastic Packages Aseptic Packaging

Heat transfer Unit Operations

- These operations are controlled by temperature gradients. They depend on the mechanism by which heat is transferred:
- Conduction: in continuous material media, heat flows in the direction of temperature decrease and there is no macroscopic movement of mass.
- Convection: the enthalpy flow associated with a moving fluid is called convective flow of heat. Convection can be natural or forced.

Heat transfer Unit Operations

- Radiation: energy transmission by electromagnetic waves. No material media are needed for its transmission.
- Thermal treatments (**sterilization and pasteurization**), evaporation, heat exchangers are studied based on these heat transfer mechanisms.

SOURCES OF MILK FOOD

1- Cows

2- Others:

buffalo, goat, sheep, camel

HOW MILK GETS FROM THE COWS TO THE STORES

Those eight steps are (in order):

1. Rearing,
2. harvesting,
3. storing,
4. transportation,
5. lab testing,
6. processing,
7. packaging, and
8. selling.

PROCESSING OF MILK

To make milk: safer more appealing or healthier

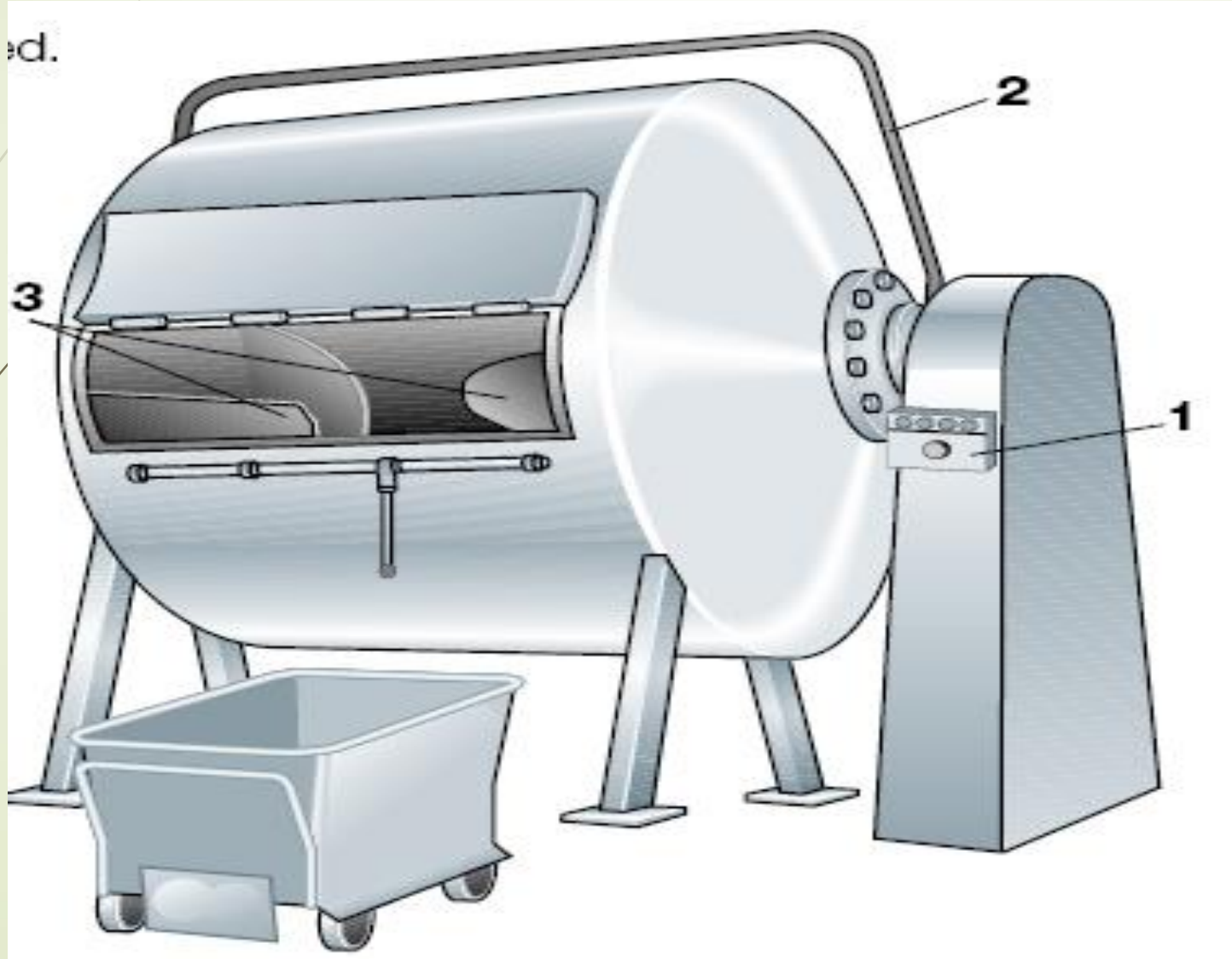
- Pasteurization,
- homogenization,
- Fortifying.

Dairy Plant Overview

Heat treatment and separation unit operations

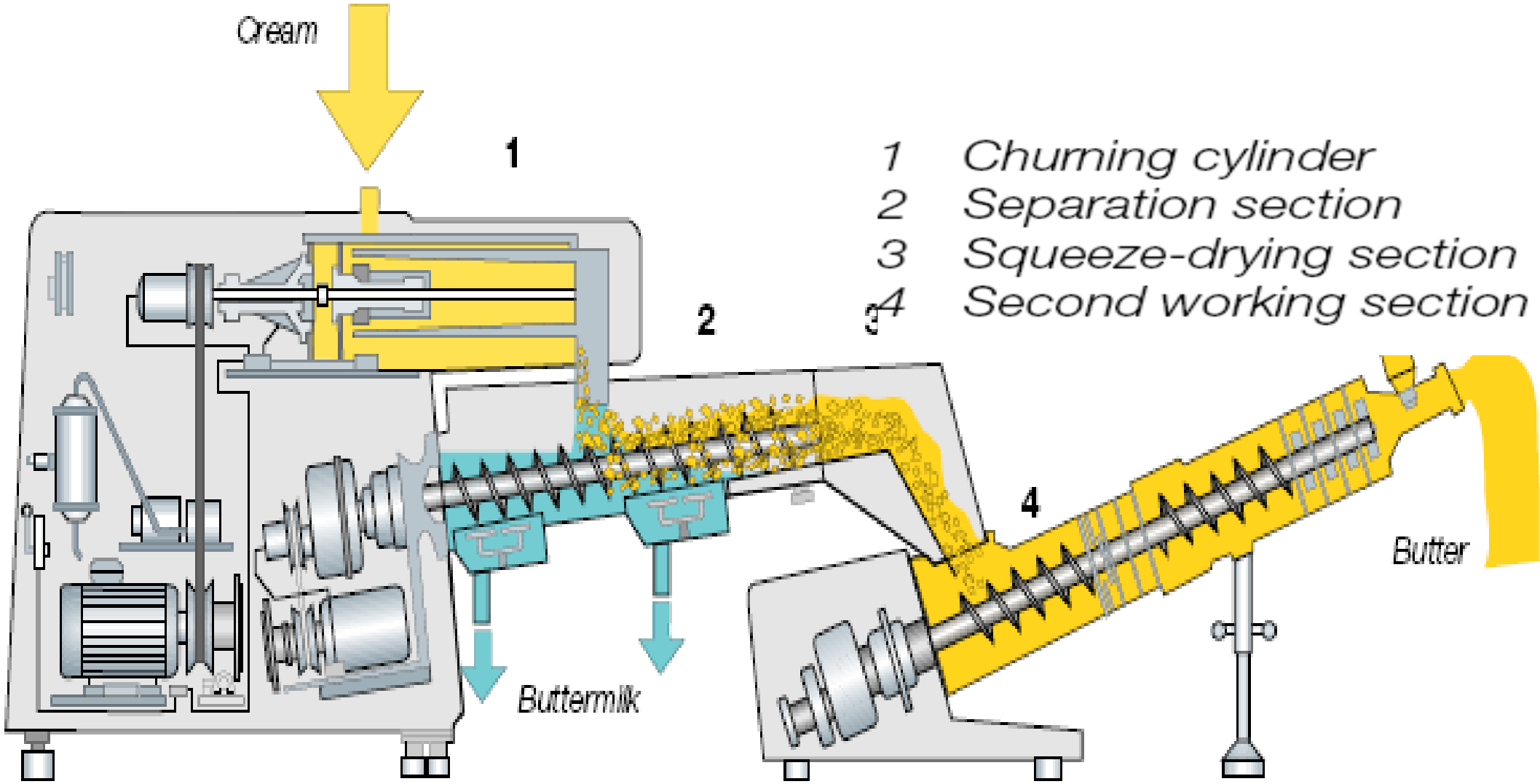
Critical Unit Operations in Dairy Processing Plant

Butter Churner for Batch Production

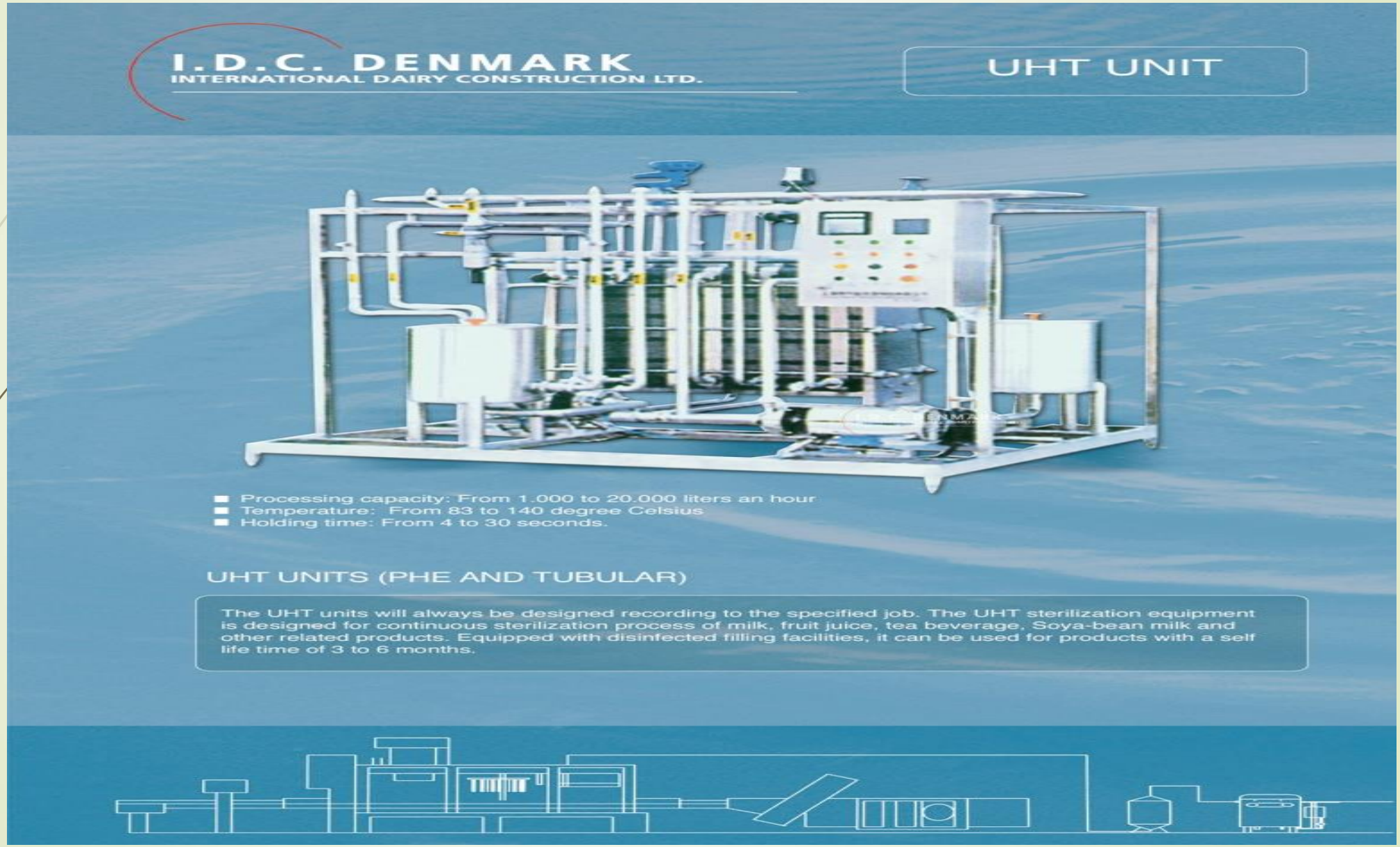


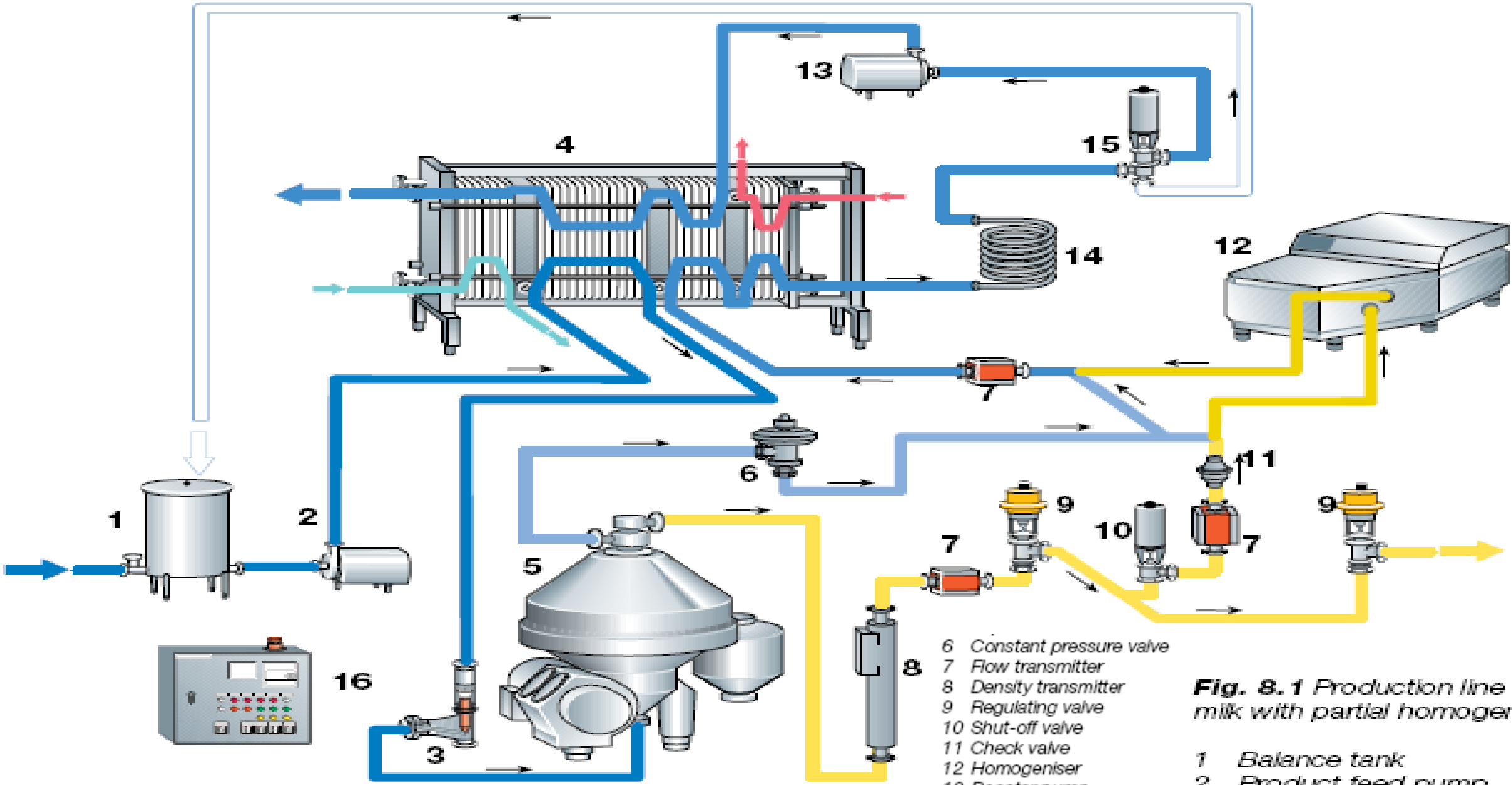
1 Control panel
2 Emergency stop
3 Angled baffles

Continuous Butter Making Machine



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.



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

Fig. 8.1 Production line for ma
milk with partial homogenisatior

1 Balance tank
2 Product feed pump
3 Flow controller
4 Plate heat exchanger
5 Separator

Milk Separation: Unit Operations in Dairy Engineering

- ✓ Cream separation
- ❑ Gravity separation

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

1- GRAVITY SEPARATION

Fat globules in milk are lighter than the plasma phase, and hence rise to form a cream layer. The rate of rise (V) of the individual fat globule can be estimated using Stokes' Law which defines the rate of settling of spherical particles in a liquid:

$$V = (r^2 (d_1 - d_2)g)/9\eta$$

where r = radius of fat globules

d_1 = density of the liquid phase

d_2 = density of the sphere

g = acceleration due to gravity, and

η = specific viscosity

1- GRAVITY SEPARATION

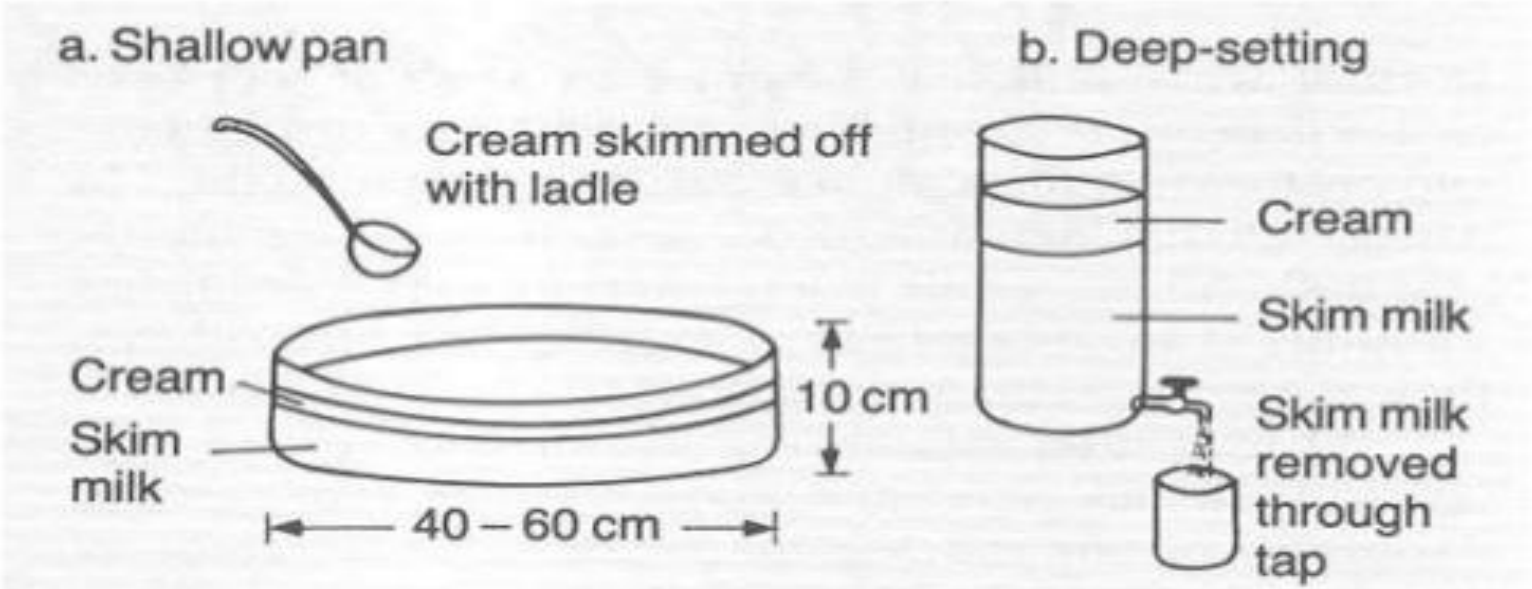


Figure 1. Batch separation of milk by gravity: (a) Shallow pan method, (b) deep-setting method

CENTRIFUGAL SEPARATION

Gravity separation is slow and inefficient. Centrifugal separation is quicker and more efficient

Involves spinning milk through a centrifuge to separate the cream from the milk. After separation, the cream and remaining milk are remixed to provide the desired fat content for the different types of milk being produced.

For "whole milk," the cream is reintroduced until the fat content reaches 3.25%. For "low fat milk," the fat content is 1%. For "skim milk" (sometimes called nonfat milk) the fat content is .05%.

Cream separation

- Centrifugal separation

$$V = \frac{r^{2\left(d_1 - d_2\right)} r_1}{9n} w^2$$

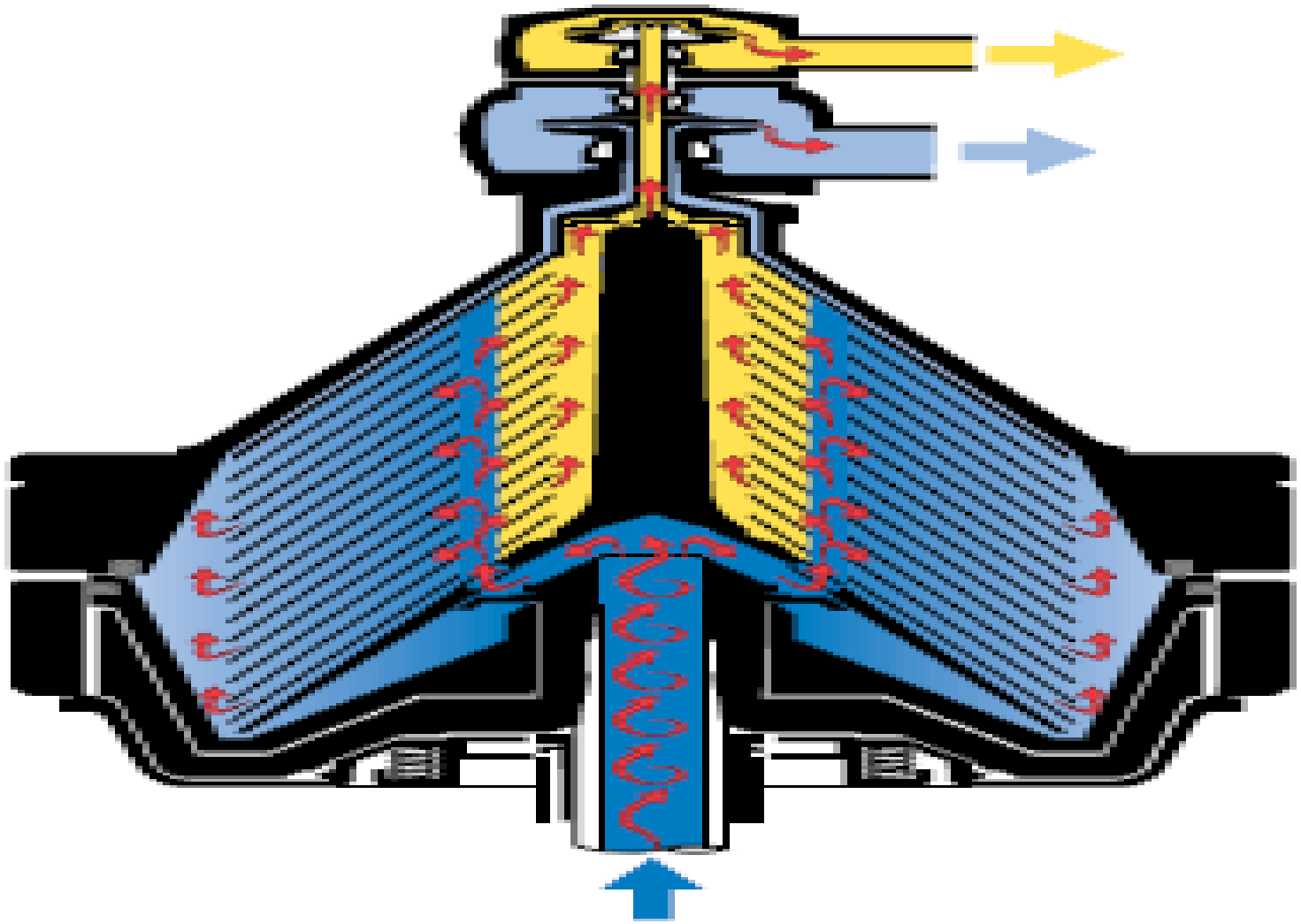


Fig. 6.2.19 In a centrifugal separator bowl the milk enters the disc stack through the distribution holes.

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

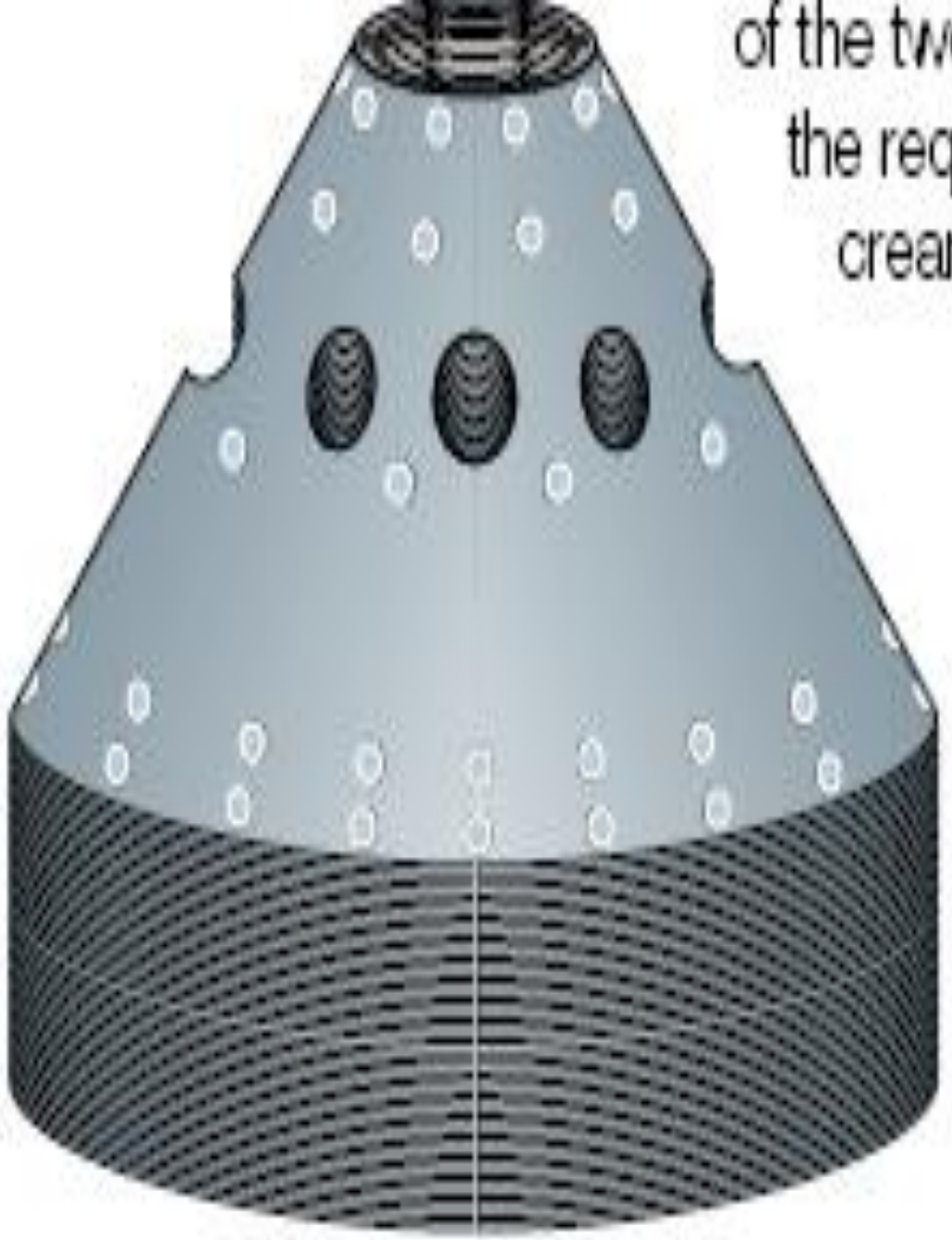
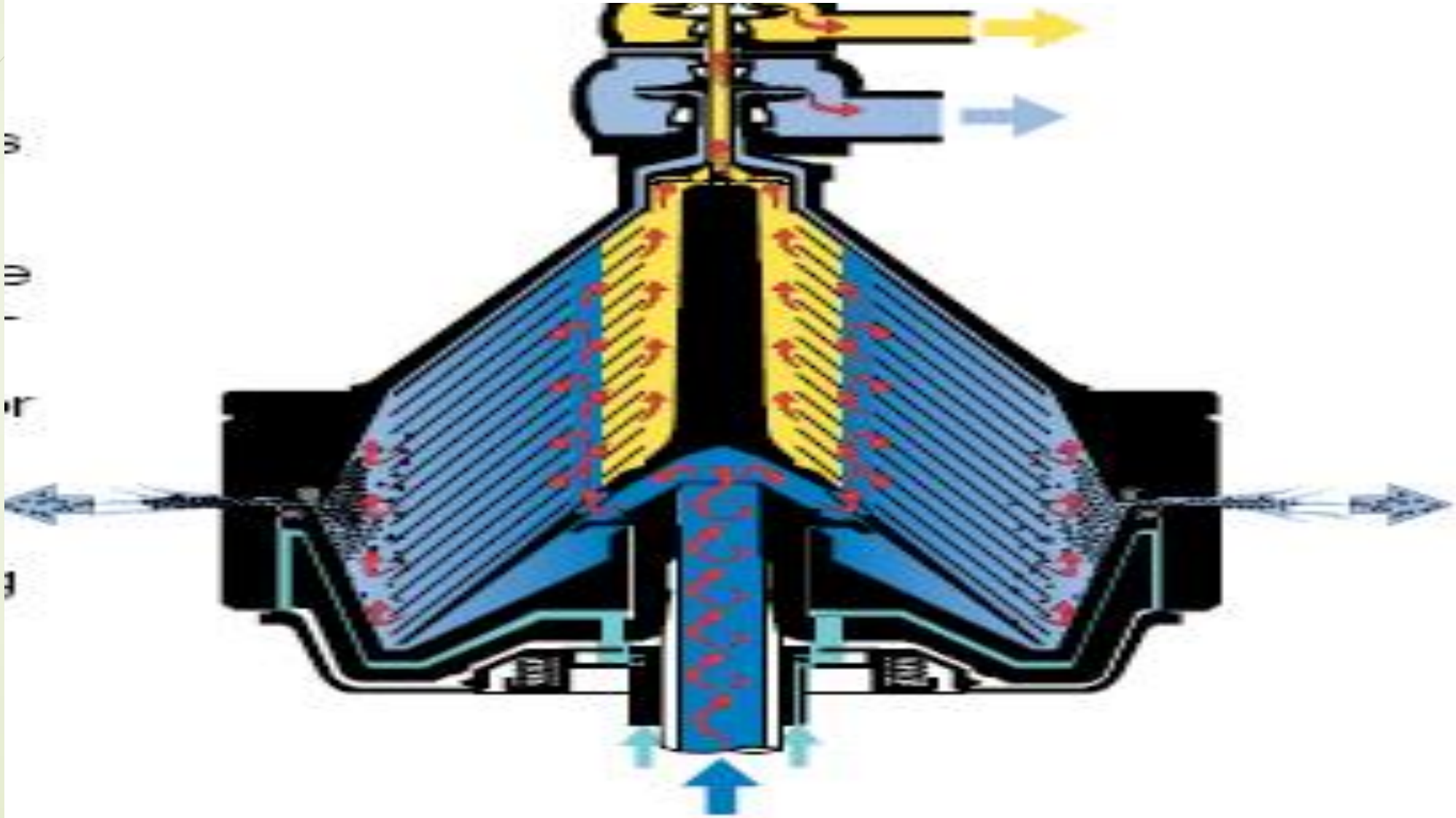


Fig. 6.2.21 *Disc stack with distribution holes and caulks.*

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



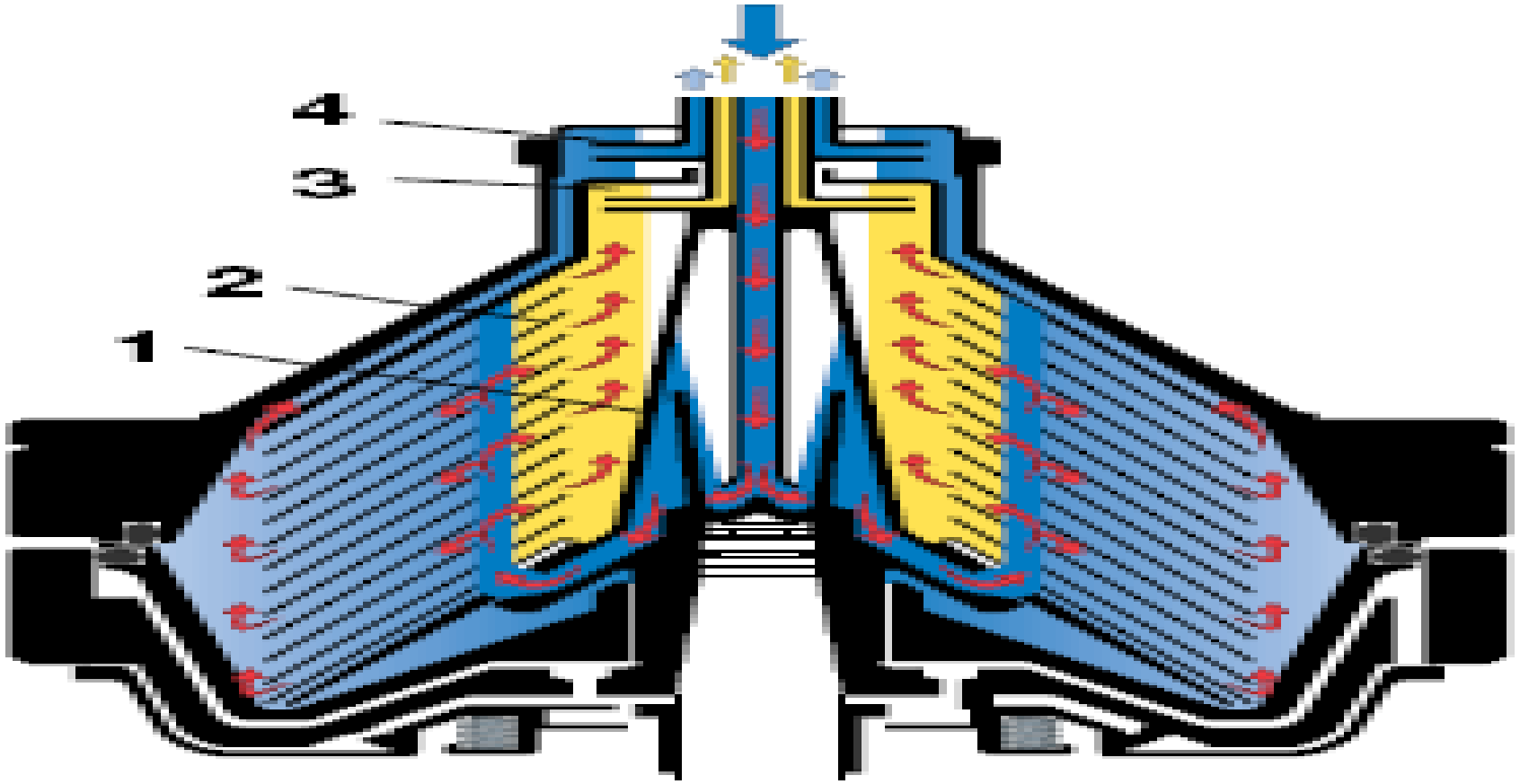
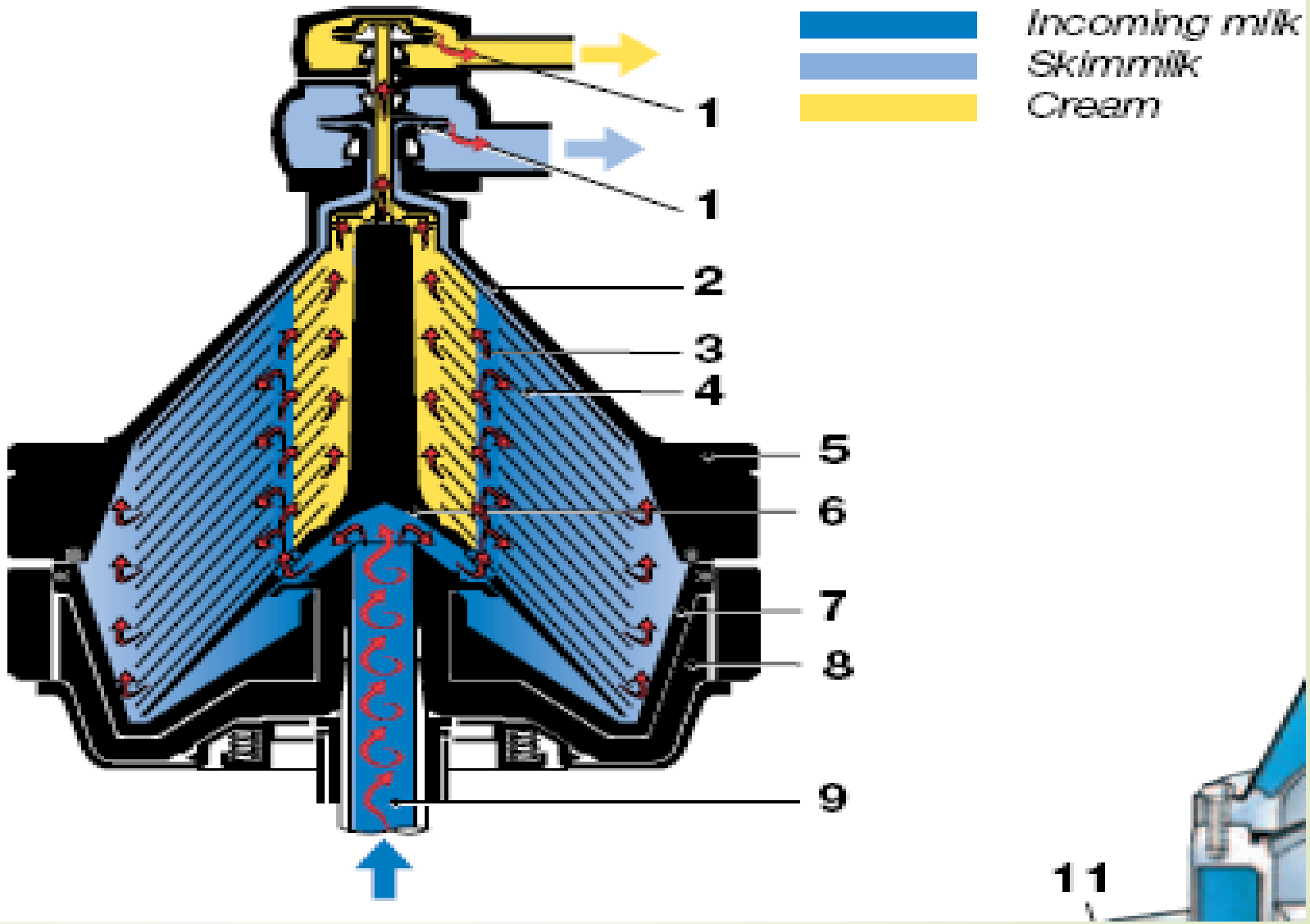


Fig. 6.2.23 *Semi-open (paring disc) self-clearing separator.*

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



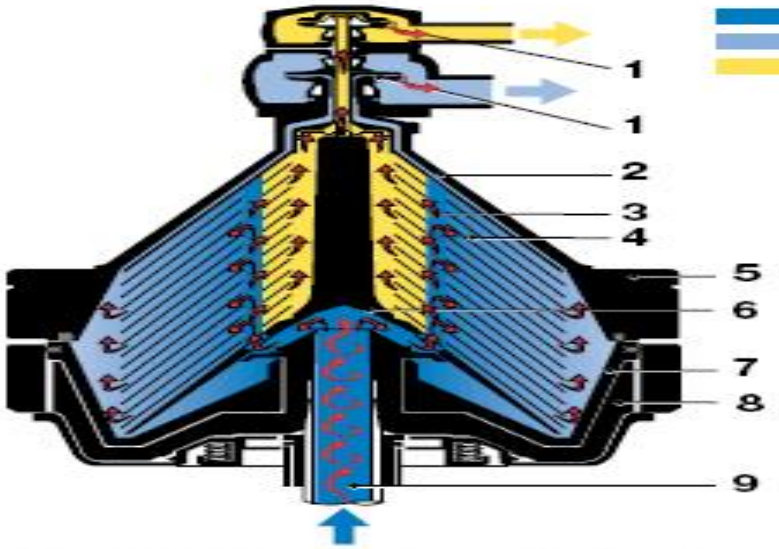


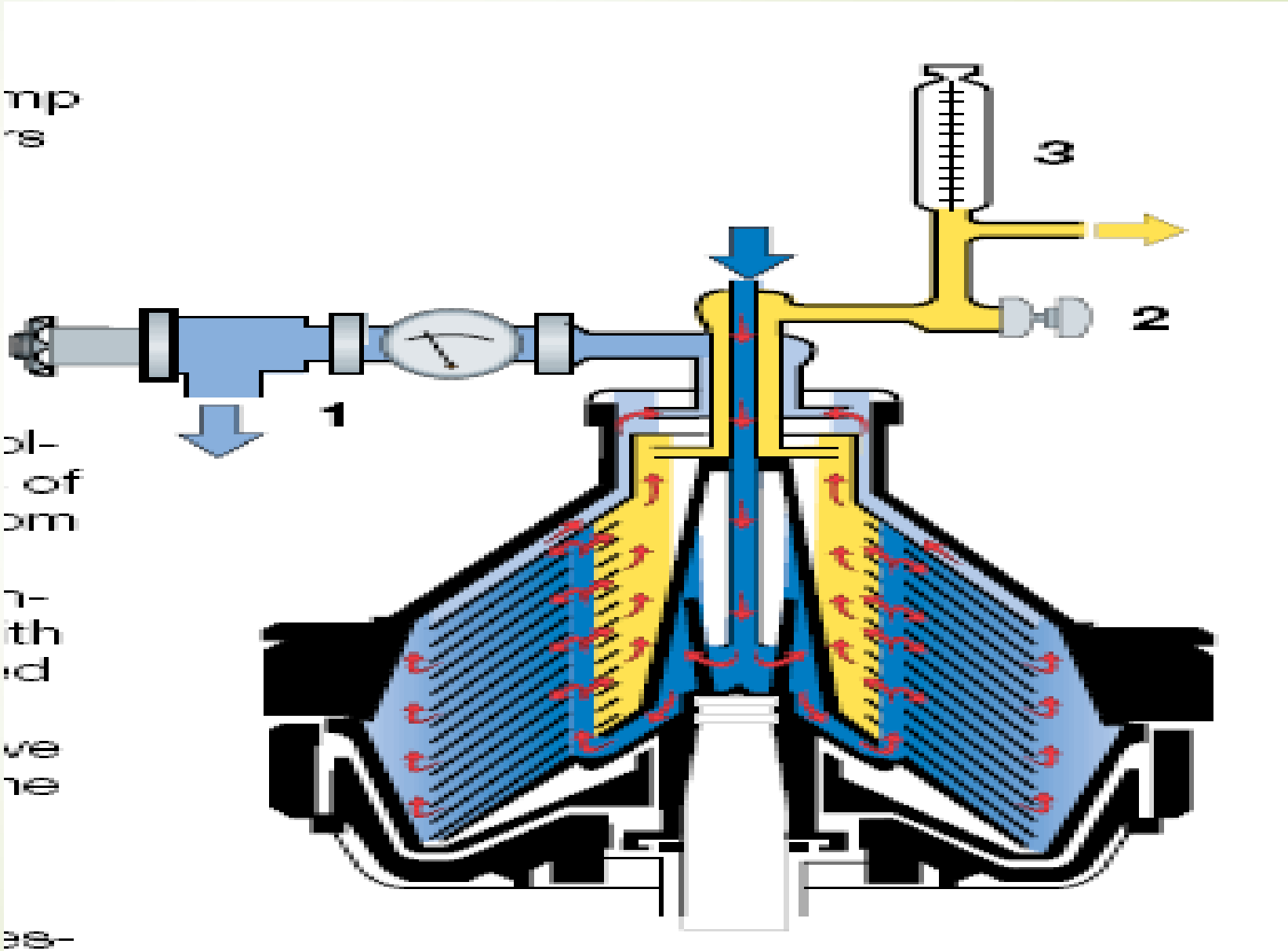
Fig. 6.2.25 *Section through the bowl with outlets of a modern hermetic separator*

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

- Cooling
- Pasteurization
- Sterilization
- Homogenization

- The most important unit operations/Machinaries in dairy processing: Chiller, cream separator, pasteurizer, sterilizer, homogenizer, Churners, Packaging, Incubation and cheese processing machineries.

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

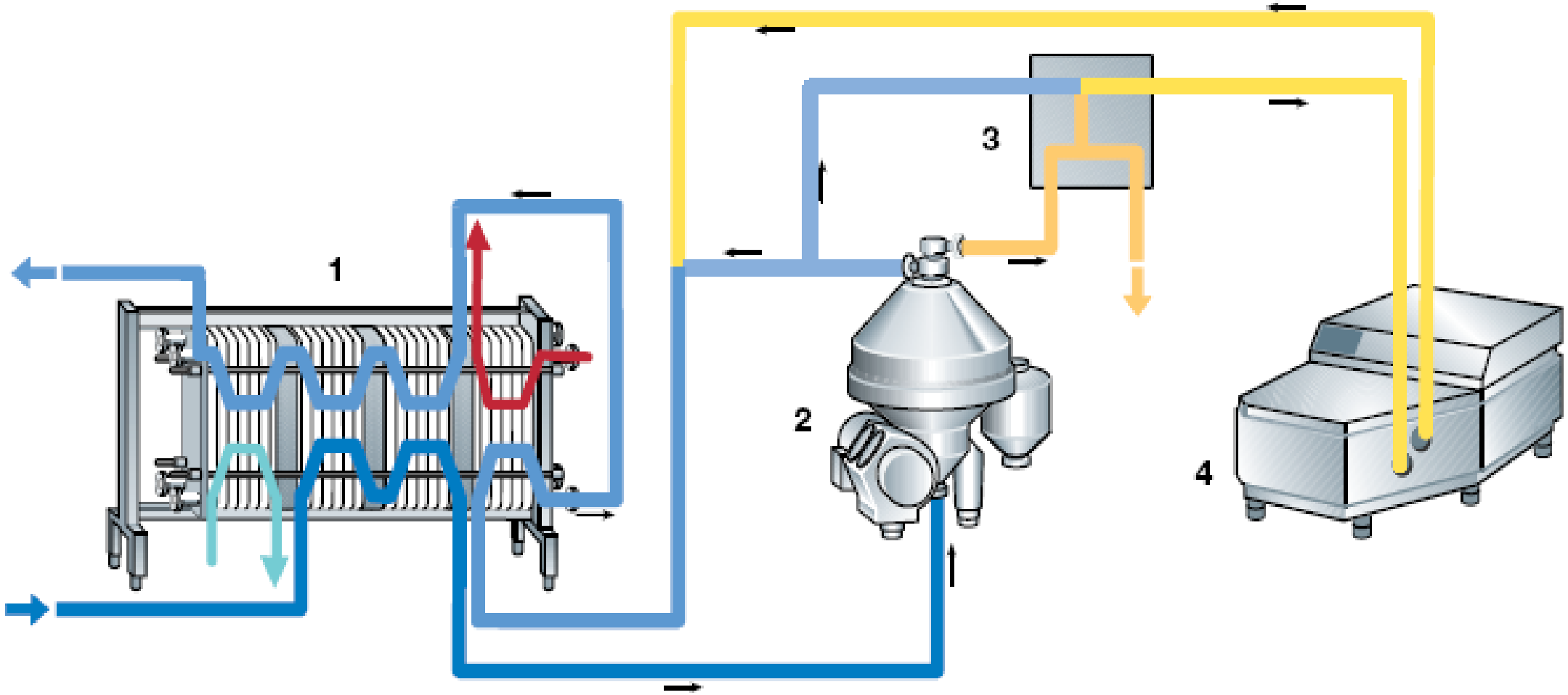


Fig. 6.3.10 *Product flow at partial stream homogenisation.*

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°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

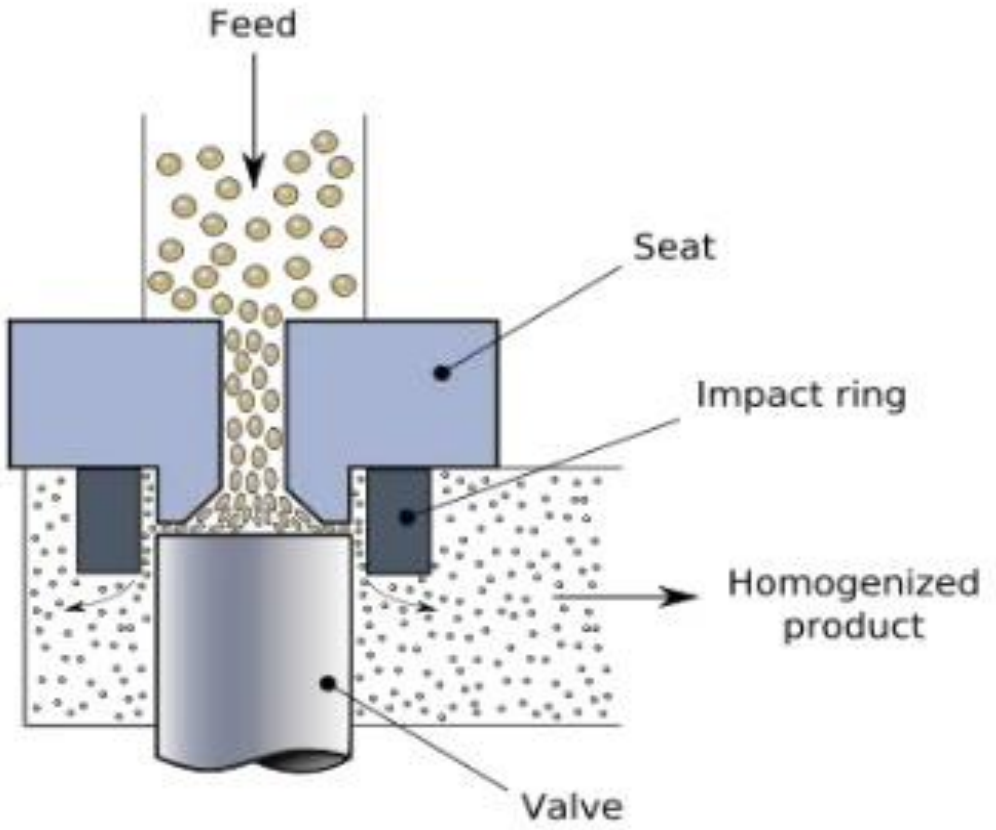
HOMOGENIZATION

Milk homogenization is accomplished by mixing massive amounts of harvested milk to create a constant, then forcing the milk at high pressure through small holes. Yet another method of homogenization uses

- extruders,
- hammermills,
- or colloid mills to mill (grind) solids.

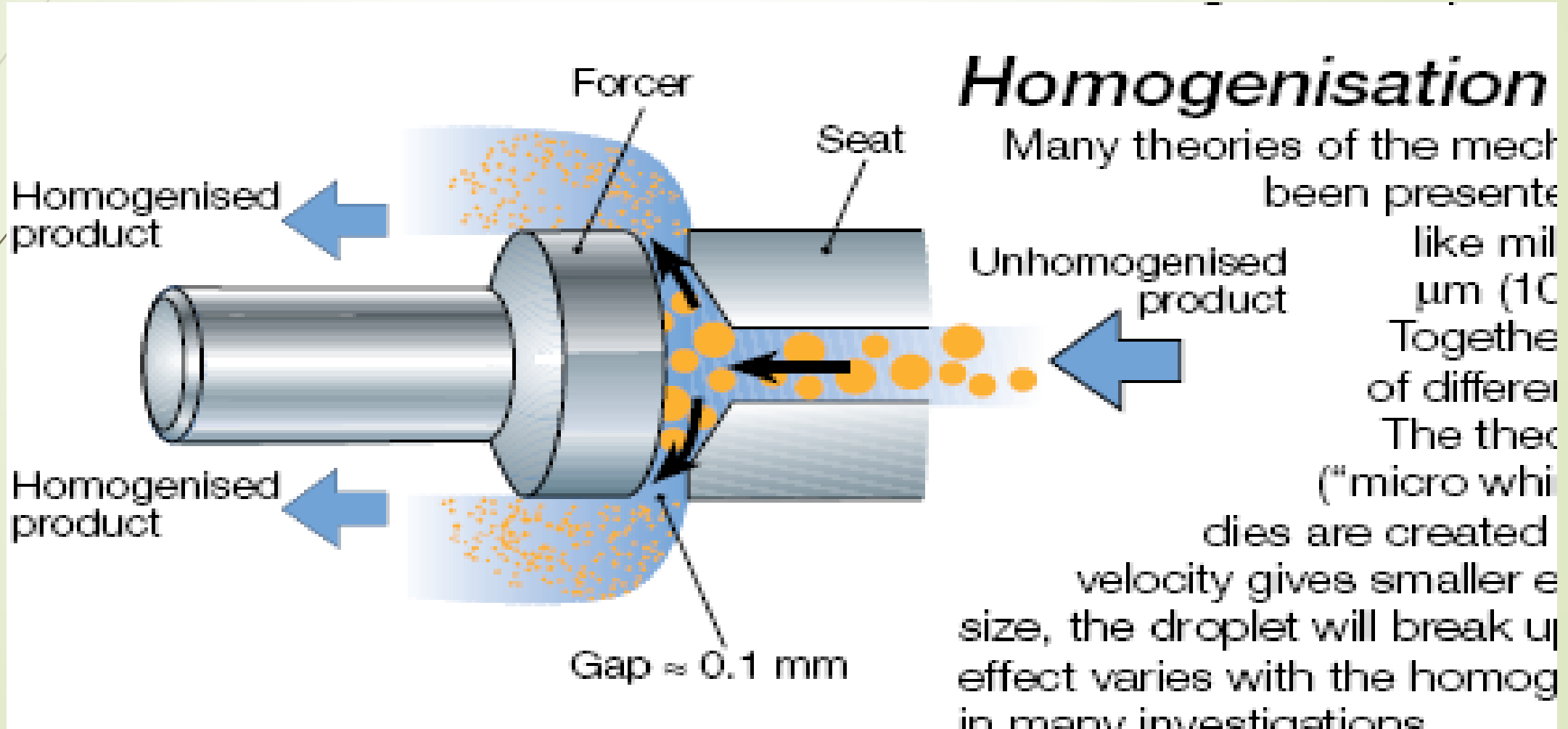
Milk homogenization is an essential tool of the milk food industry to prevent creating various levels of flavor and fat concentration.

HOMOGENIZATION

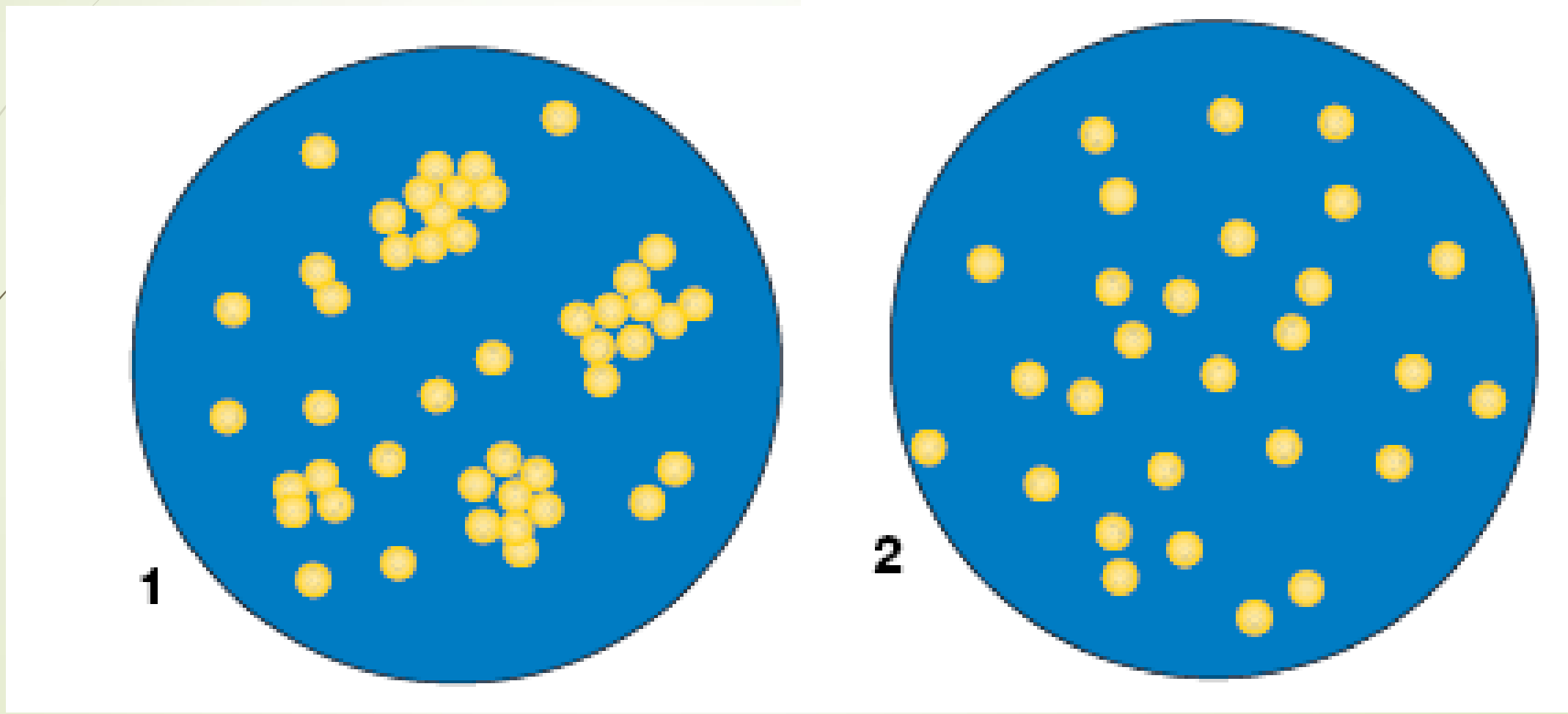


Homogenizing valve, a method to homogenize at high pressure.

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 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

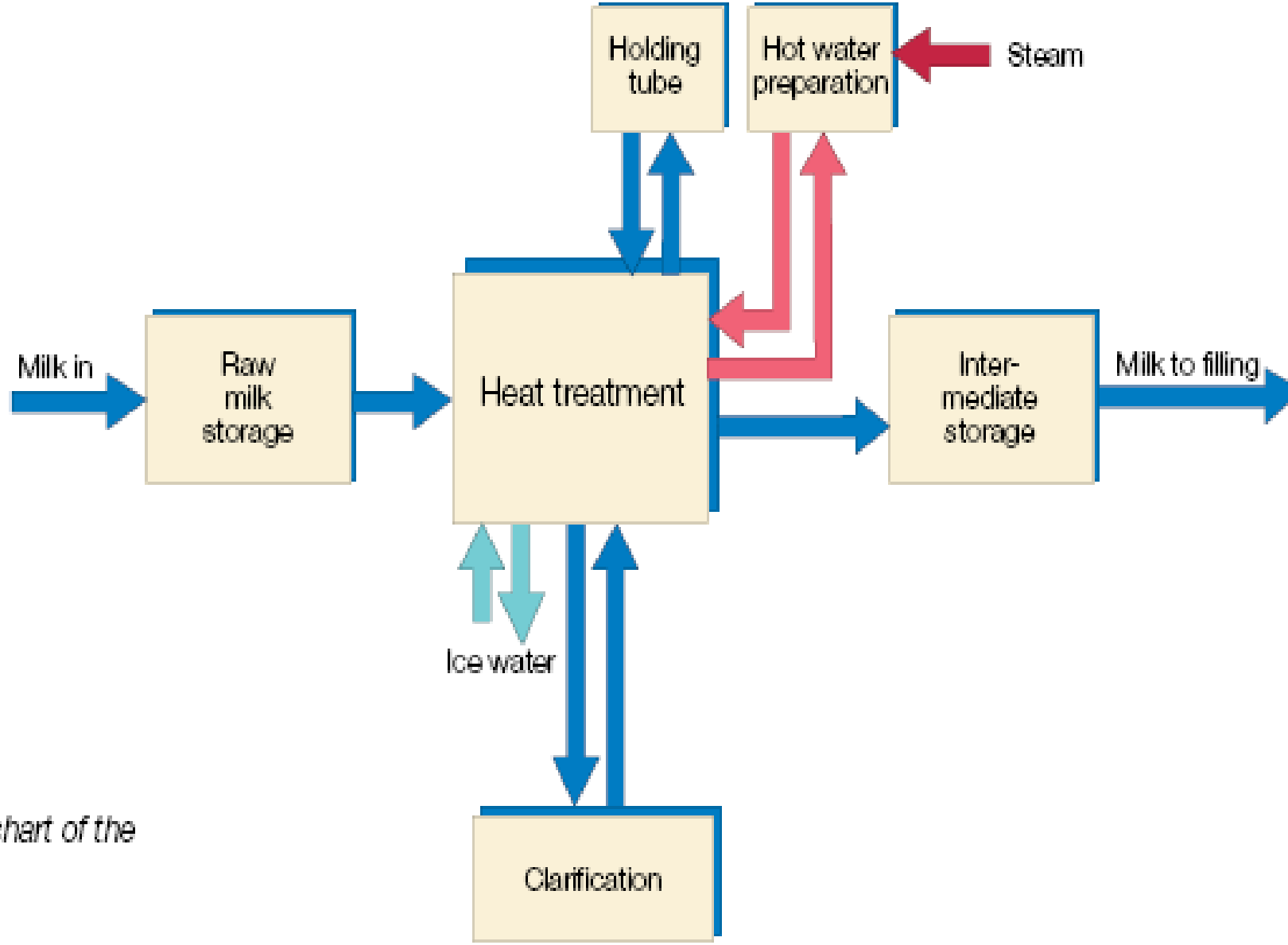


Fig. 7.1 *Generalised block chart of the milk pasteurisation process.*

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

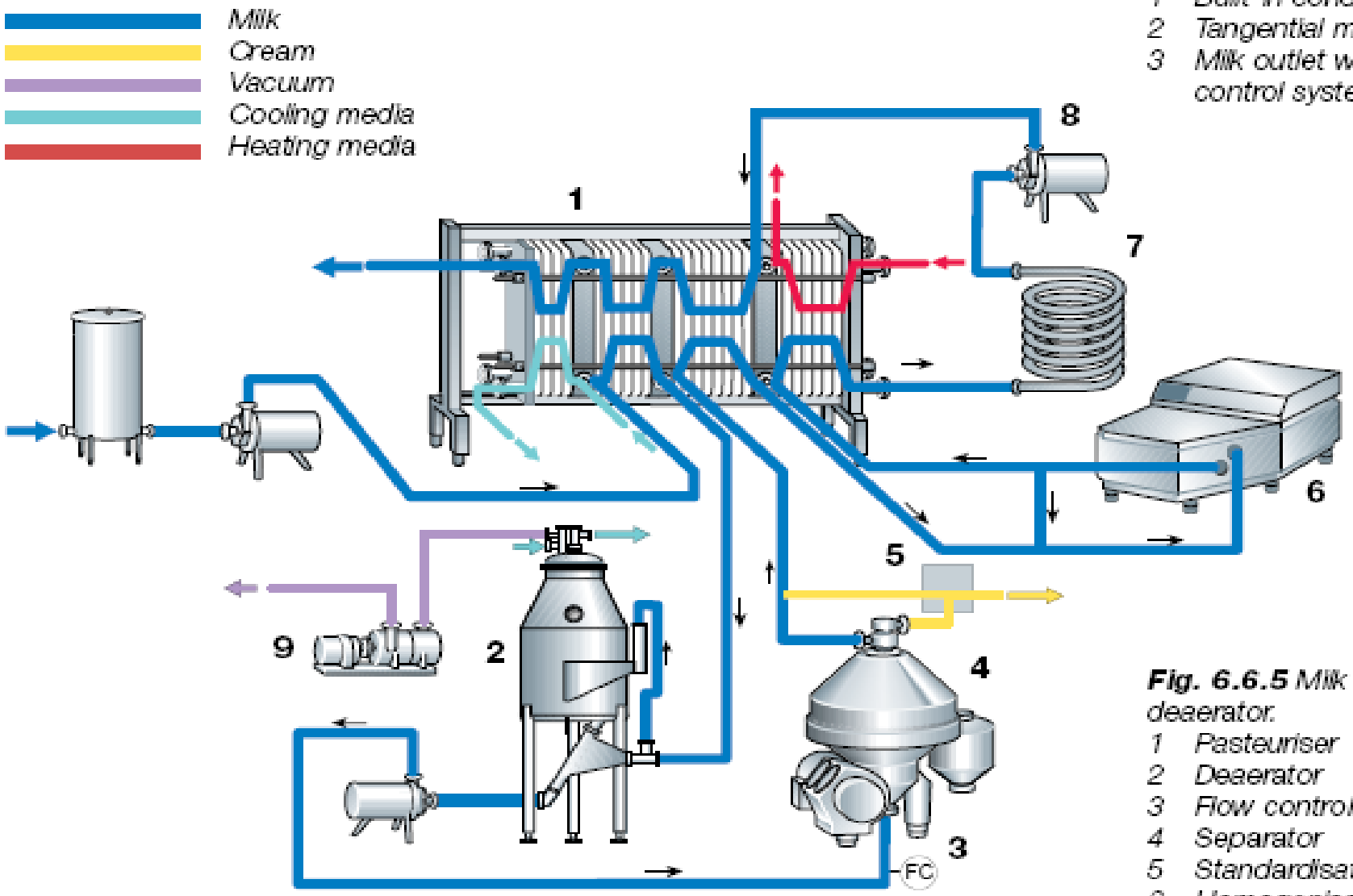


Fig. 6.6.4 *Flow of milk and air in the vacuum deaerator with built-in condenser.*

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*

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.

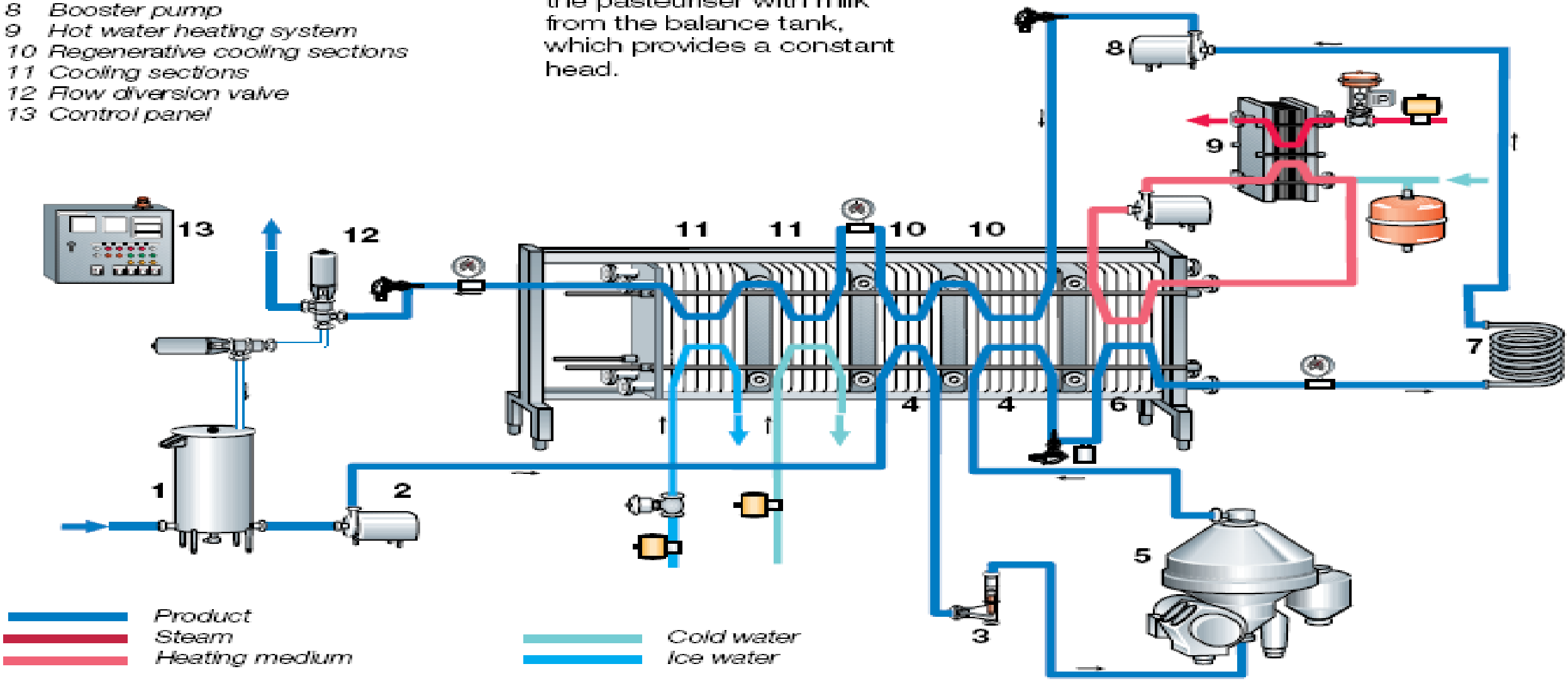
The milk is replaced by water and the pasteuriser shuts down when circulation has continued for a certain time.

Feed pump

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

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*



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 19^{th} : 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
- **2.Industrial manufacture of butter**
- 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

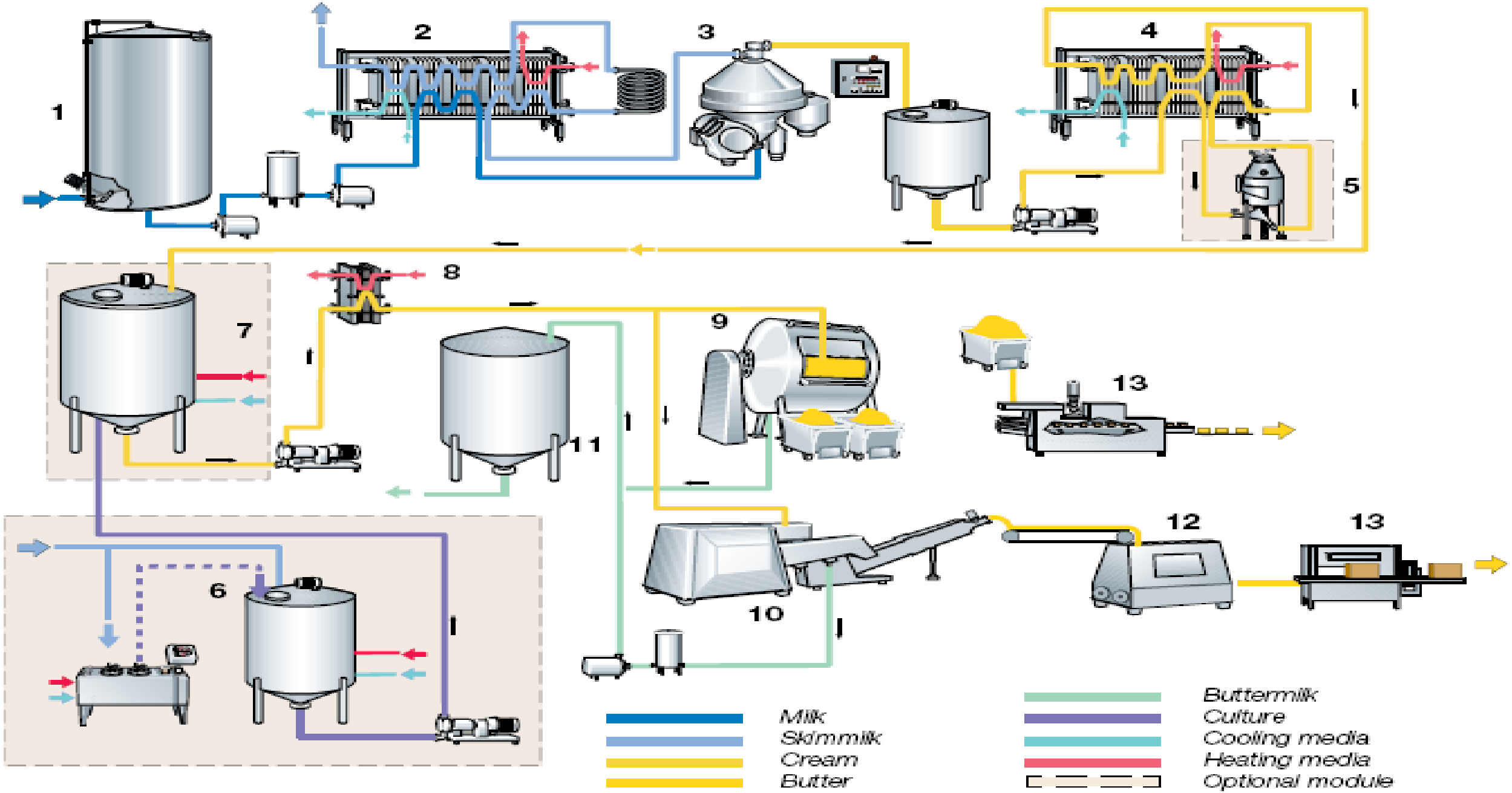
- Ripening of cream refers to the fermentation of cream with the help of desirable starter cultures
- The butter starter culture contain lactic acid producers such as *Str.lactis* and/or *Str.Cremoris*, together with aroma (diacetyl) producers (*Str.diacetilactis*) with 0.5-02.0 %, 15-16hr,15^{0}C
- 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 (Milk processing unit operations in dairy plant)

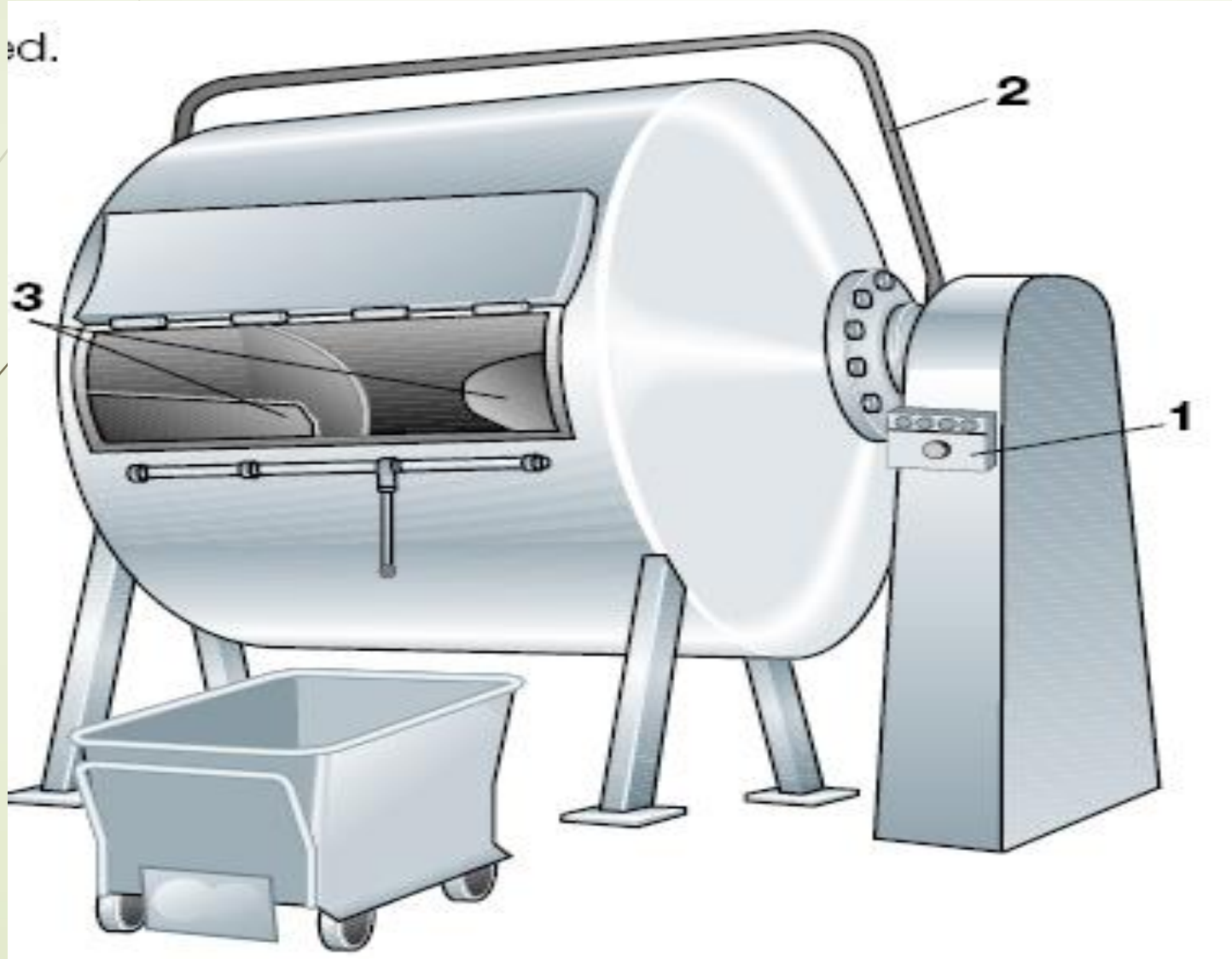
- Butter churner
- Butter packing machine
- Continues butter-making machines (efficient)

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

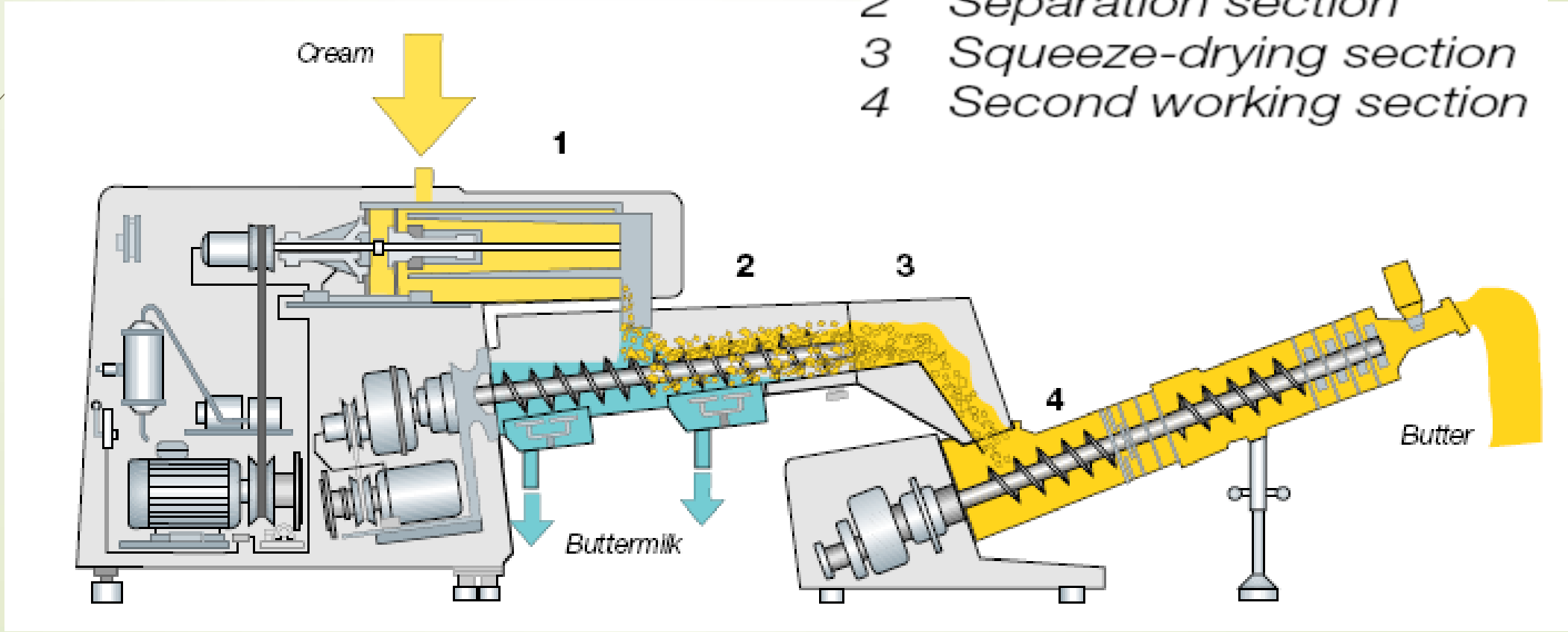
Butter Churner for Batch Production



1 Control panel
2 Emergency stop
3 Angled baffles

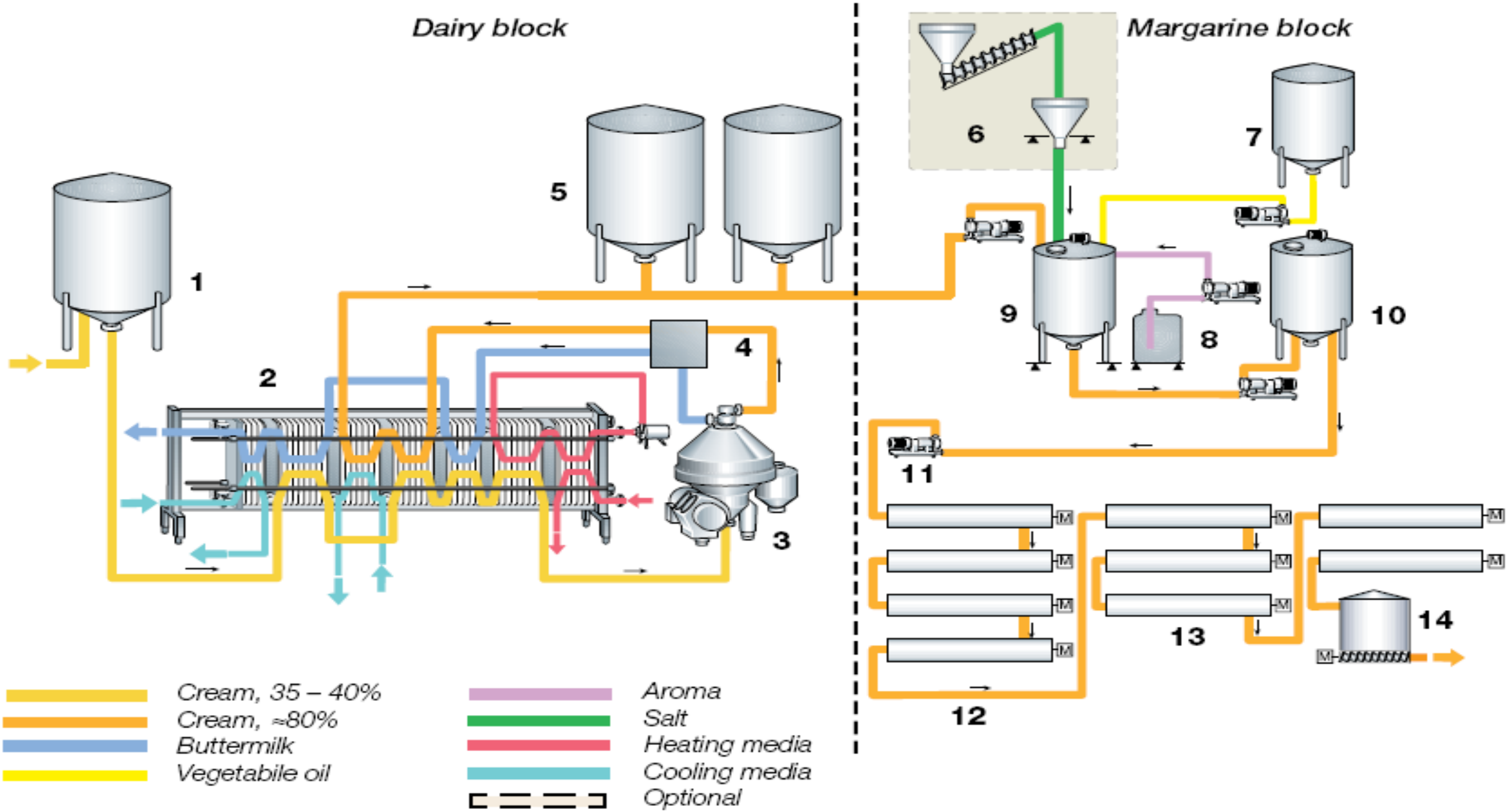
A continuous Butter Making Machine

1 Churning cylinder
2 Separation section
3 Squeeze-drying section
4 Second working section



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
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

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

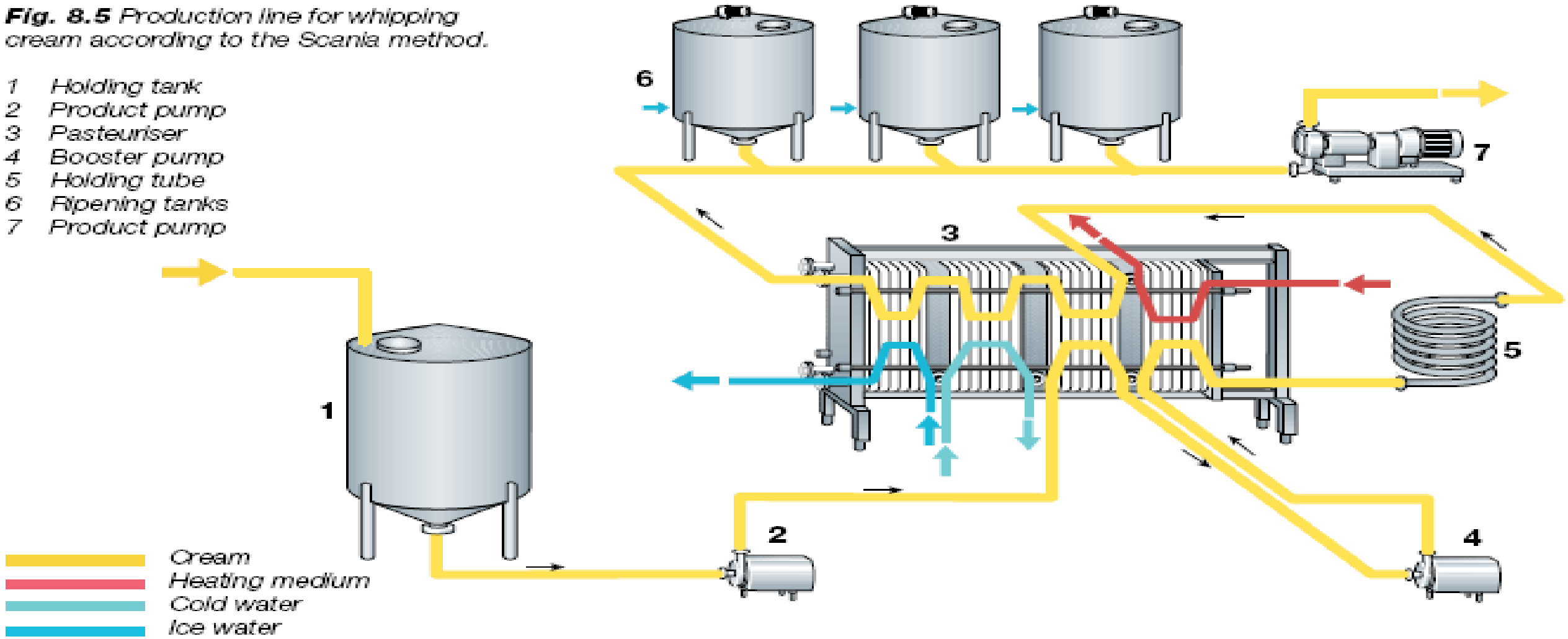
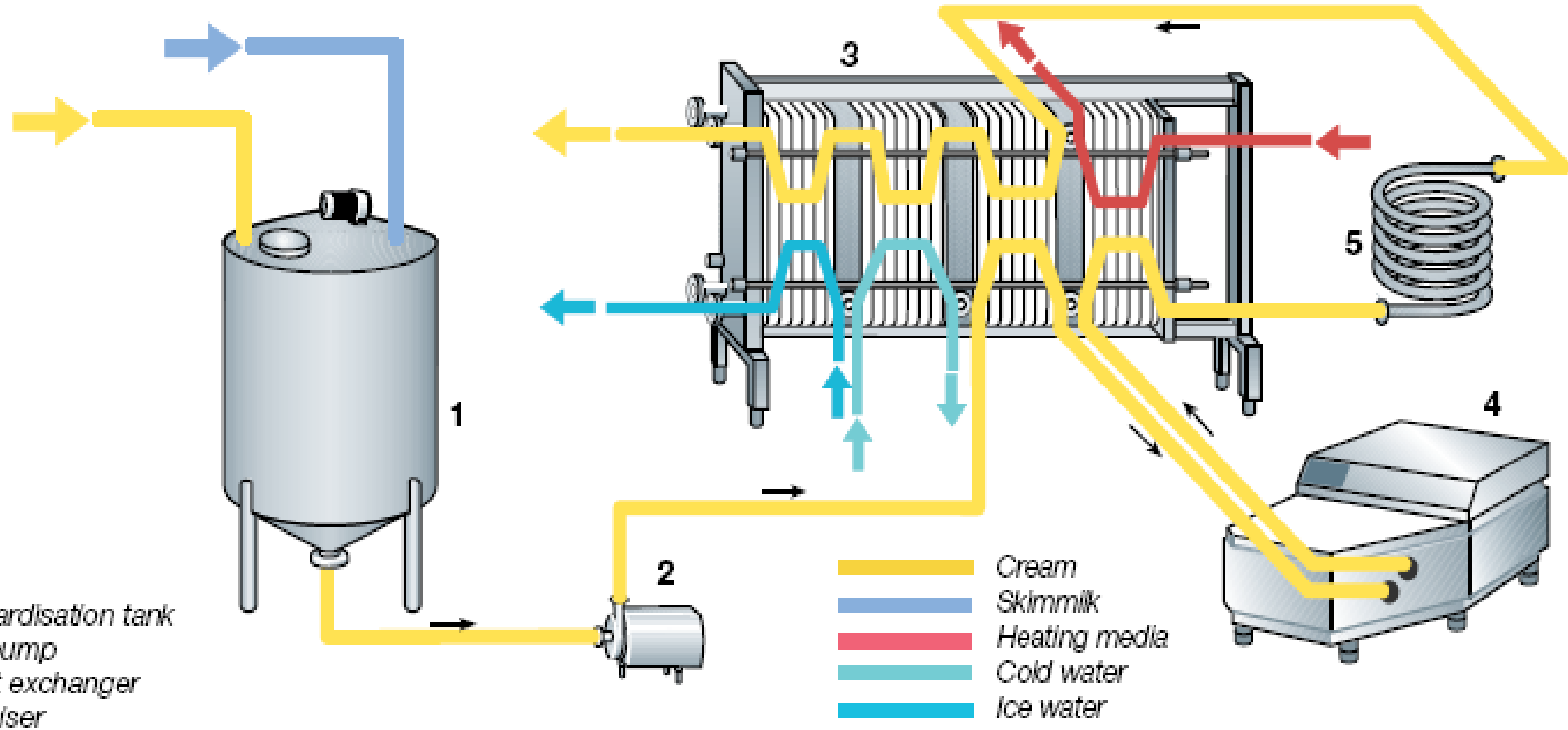
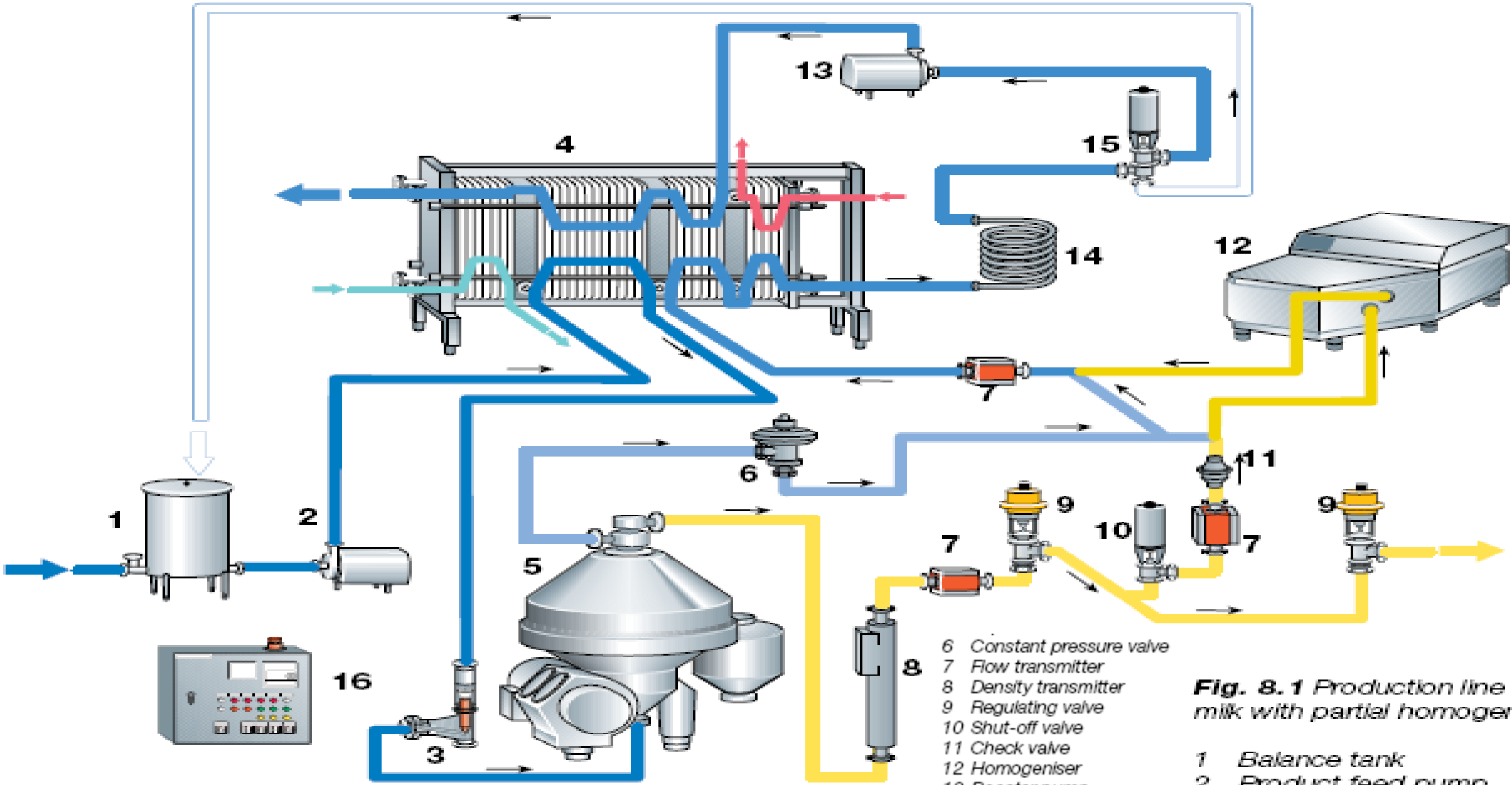


Figure 8.5 shows a process in which great care has been taken to eliminate rough treatment of the whipping cream. This method, developed by Alfa Laval in collaboration with some Swedish dairy co-operatives, is called

Production line for Half and Coffee Cream



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



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

Fig. 8.1 Production line for ma
milk with partial homogenisatior

1 Balance tank
2 Product feed pump
3 Flow controller
4 Plate heat exchanger
5 Separator

Pasteurization plant supplemented with Bactofugation or micro-filteration plant

plemented with a bactofugation or a microfiltration plant.

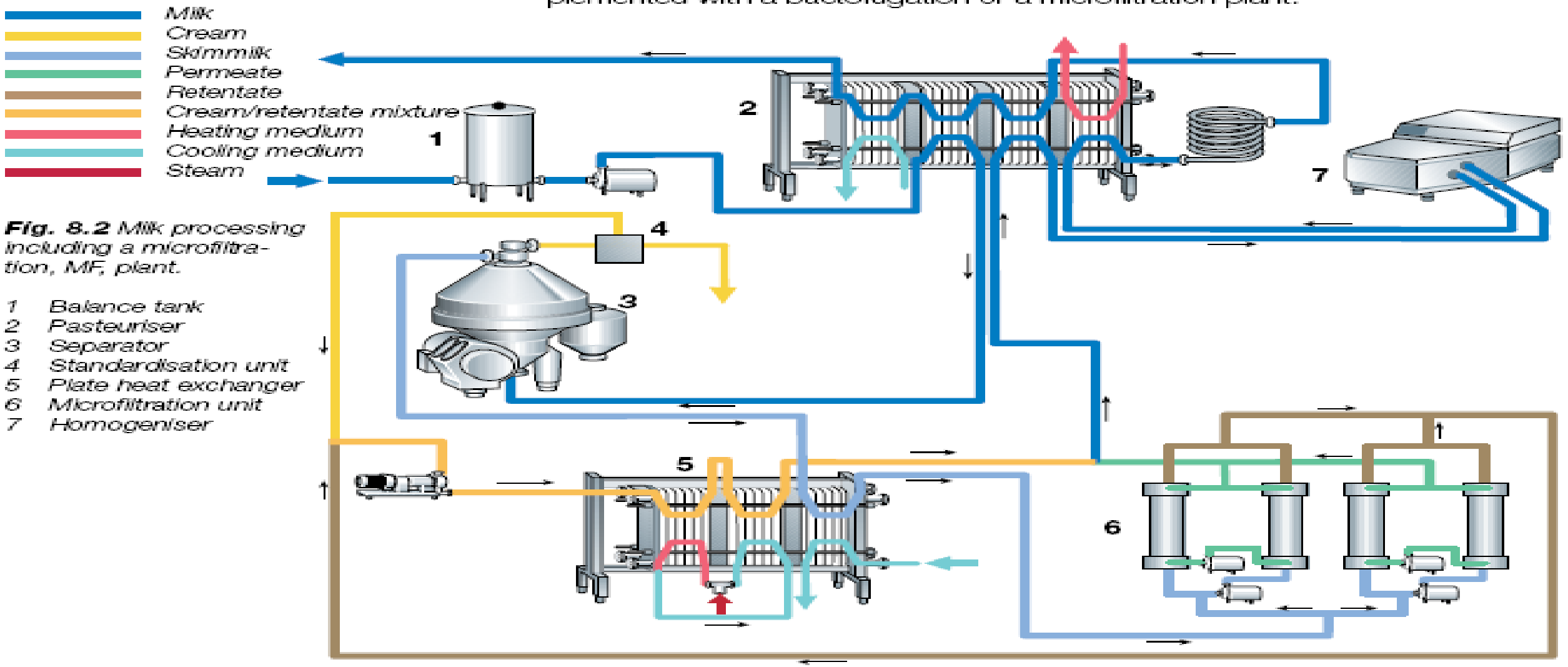
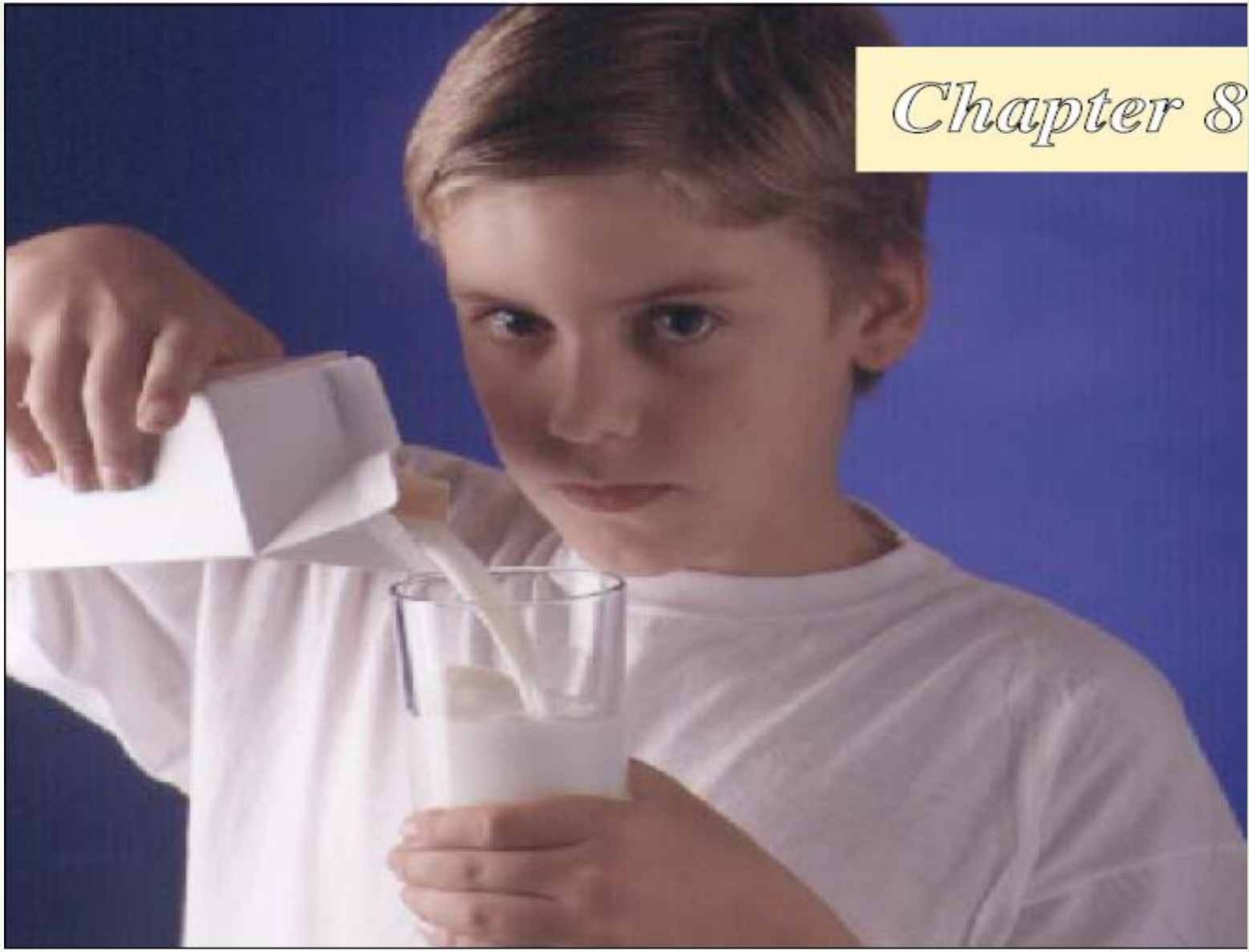


Fig. 8.2 *Milk processing including a microfiltration, MF, plant.*

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



Pasteurised milk products

Milk processing unit operations in dairy plant: A revision

Rice and Coconut milk

Introduction

Milk is the food which exclusively sustains us during the first few months of life.

Raw milk

The lacteal secretion , practically free from colostrum, obtained by the complete milking of one or more healthy cows(PMO).

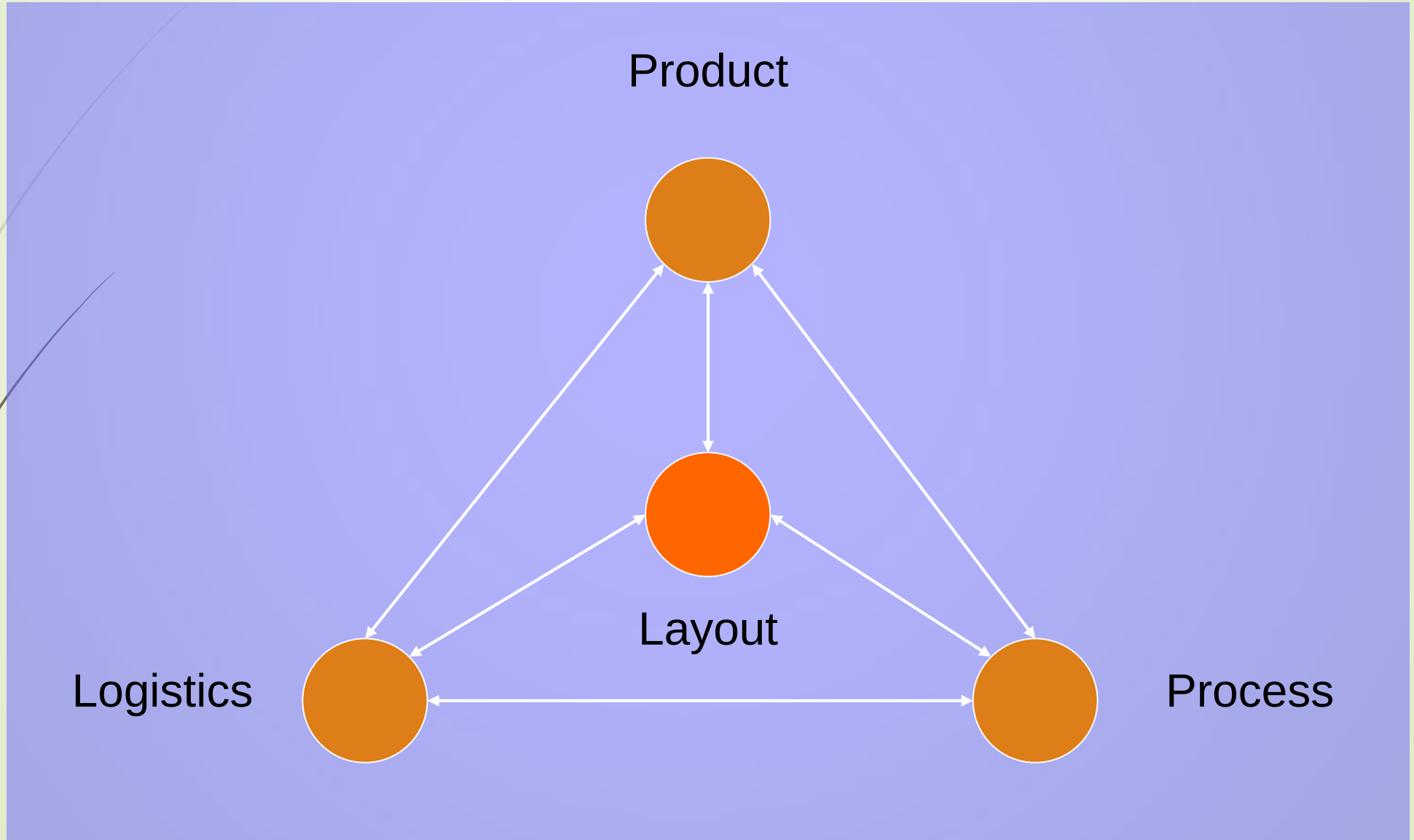
- The term *milk* is also used for white colour, non-animal beverages resembling milk in colour & texture such as soy milk, rice milk, almond milk, & coconut milk.

Whole milk transportation

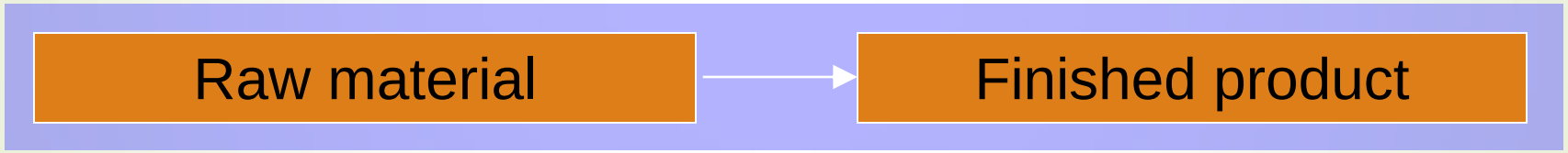
Milk Tankers

The milk is taken from the farm by a refrigerated tanker to a factory to be pasteurised and bottled.

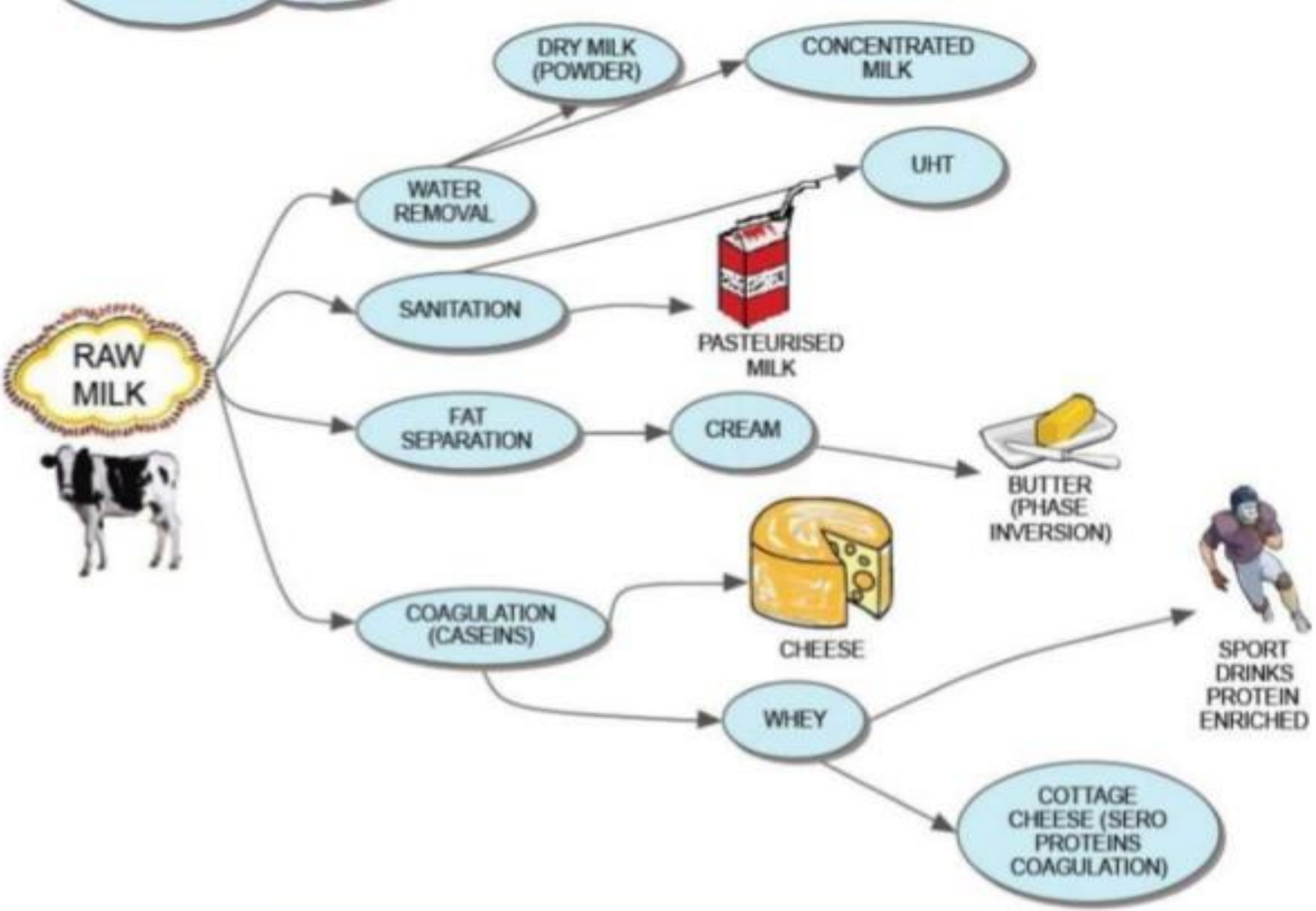
Design



Flow analysis



Layout facilitates this flow


DRY MILK (POWDER)
CONCENTRATED MILK
WATER REMOVAL
UHT
SANITATION
PASTEURISED MILK
RAW MILK
FAT SEPARATION
CREAM
BUTTER (PHASE INVERSION)
COAGULATION (CASEINS)
CHEESE
SPORT DRINKS PROTEIN ENRICHED
WHEY
COTTAGE CHEESE (SERO PROTEINS COAGULATION)

1. 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 55-60ºC
- Microfiltration
  - Micro-filter membranes of 1.4 μm or less can lead to reduction of bacteria
  - and spores up to 99.5-99.99%.

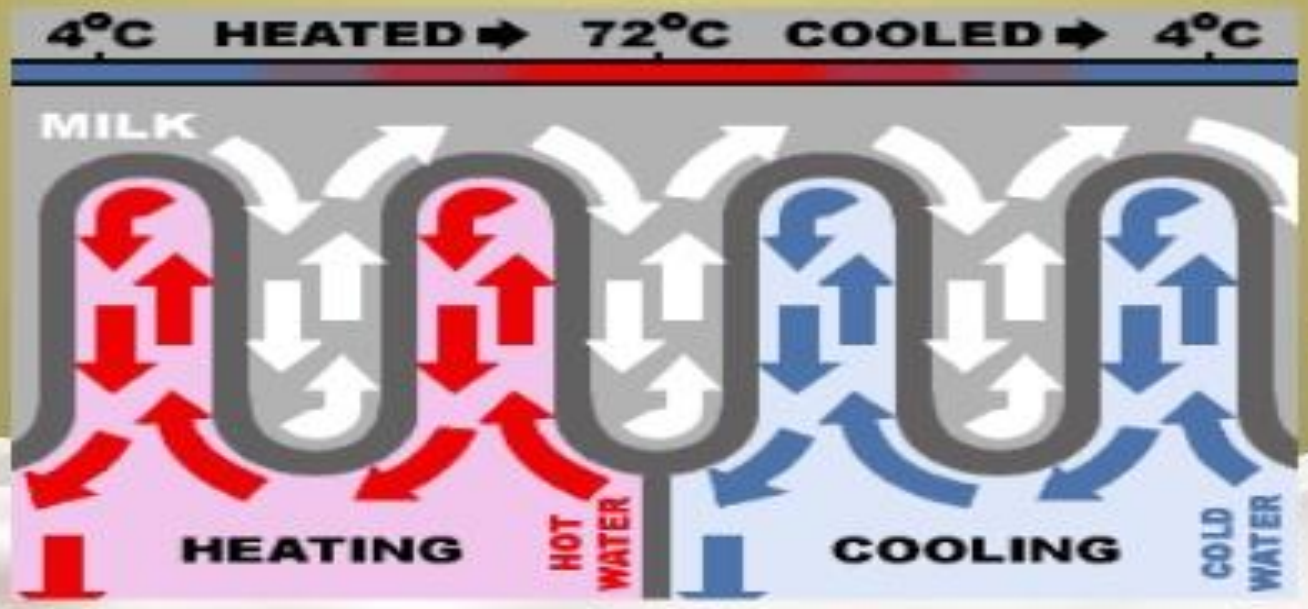
2. Homogenization

- ***Function*** *:* to *prevent creaming*, or the rising of fat to the top of the container of milk.
- The process of homogenization permanently *emulsifies* the fine fat globules by a method that pumps milk under high pressure [2000–2500 lb/in2 (psi)] through small mesh orifices of a homogenizer.
- Homogenization *mechanically* *increases the number & reduces the size of the fat globules*. The size is reduced to 1/10 of their original size.
- *Resulting* in the milk that maintains more uniform composition with improved body and texture, a whiter appearance, richer flavor, & more digestible curd.

3. Pasteurisation

- Pasteurisation is a relatively mild heat treatment, sufficient to destroy disease-causing microorganisms and inactivate enzymes to extend its shelf life.
- It should be followed by immediate cooling of product to the temp. sufficiently low to check the growth of microorganisms which are resistant to temp. used.

- pasteurisation causes minimal sensory and nutritive changes in the food. Some vitamin levels are reduced, mainly vit B_1 & vit C.



Different pasteurisation methods

1. **Low-temperature-longer time(LTLT)**
   - 65°C for 30 minutes, called the Holding or Batch method
2. **High-Temperature-Short-Time (HTST)**
   - heat treatment of 72°C for 15 seconds is applied, followed by rapid cooling to below 10°C. Also called the continuous system or flash pasteurisation.
3. **Ultra High Temperature (UHT)**
   - 149.5°C for 1 second or 93.4°C for 3 sec.

Pasteurisation

The milk is pasteurised
to kill any bacteria,
by heating it to 71 C for
15 seconds.

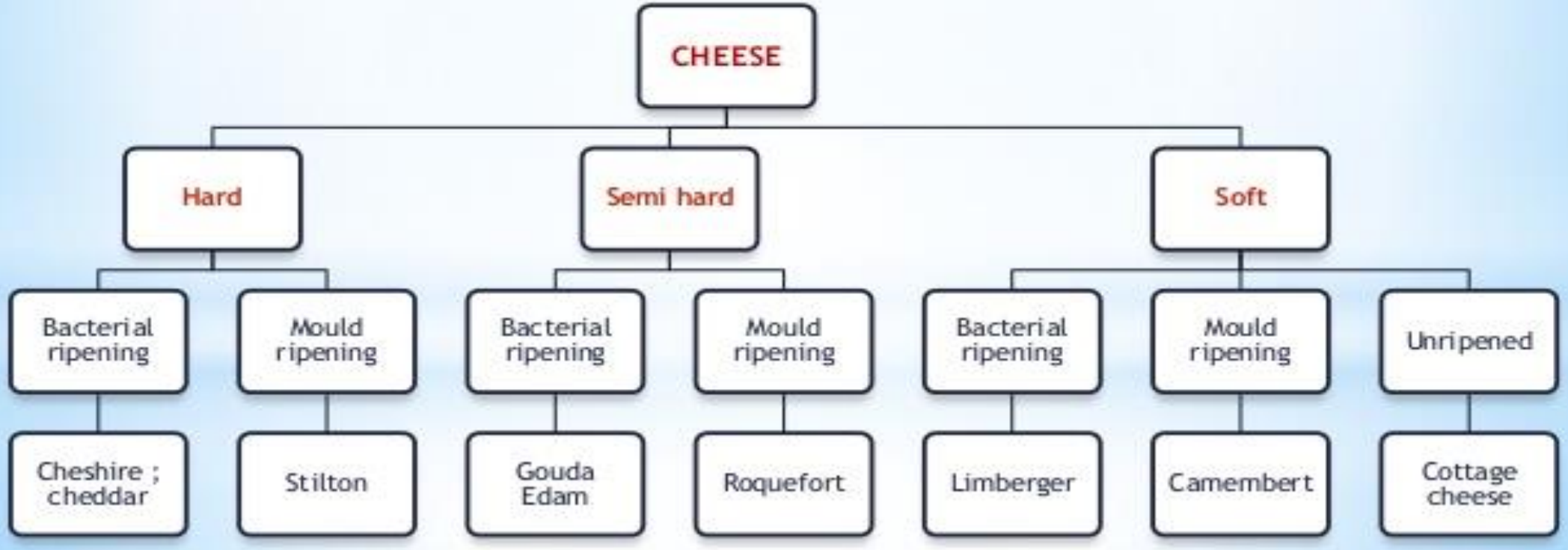
It is then put into bottles
or cartons and sold in the shops.

I like milk in my tea.

Cheese is made up of casein. Varieties of cheese are differentiated according to their

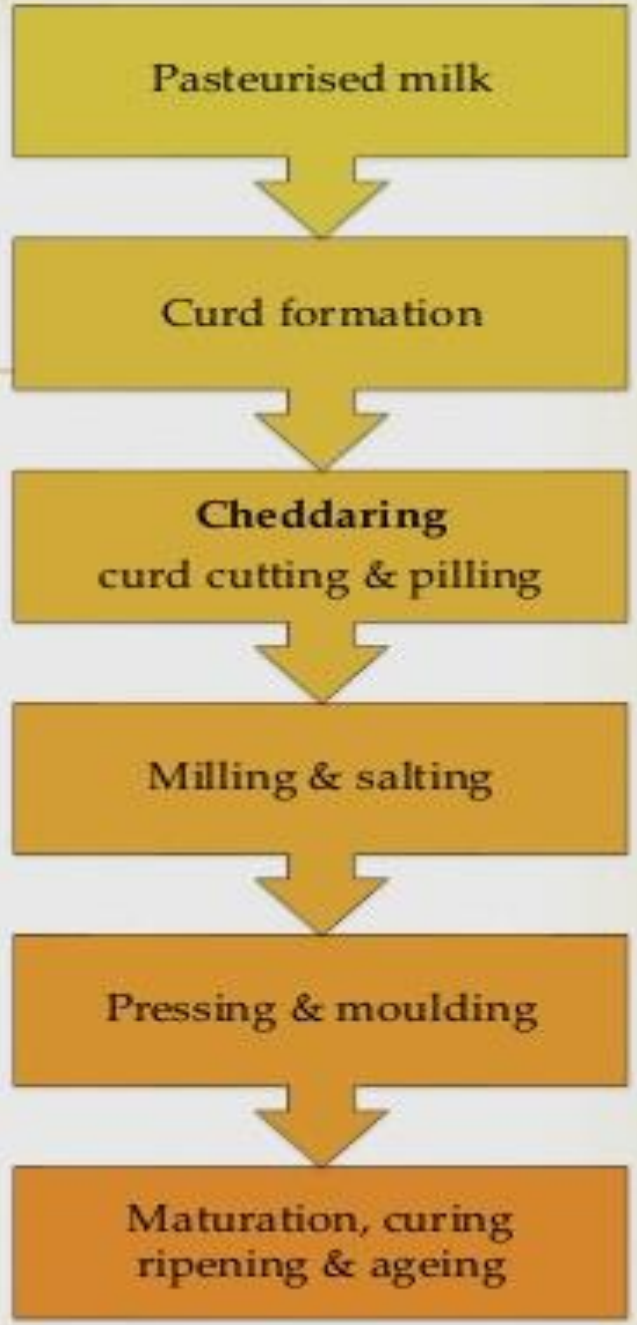
* Flavour
* Texture
* Type of milk

* Salts & seasoning added
* Type of bacteria & mould species used in ripening
* Manufacturing & processing method



Production of cheese

- **Curd formation:** pasteurised whole milk is brought to a temperature of 31'C, starter & required colouring matter is added. After 30 min rennin is added, stirred & allowed to set curd.
- **Curd cutting:** into small cubes
- **Curd cooking:** heated to 38°C & held for 45 min. curd is stirred to prevent matting.
- **Curd drainage:** whey is drained off & curd is allowed to mat.
- **Cheddaring:** cutting matted curd into blocks turning them at 15 min interval & then piling. It is then passed to curd mill which cuts the slab into strips.
- **Salting the curd:** to draw out the whey from curd & as preservative.
- **Pressing**: overnight



Unit Operations and Dairy Foods Processing

- What are the unit operations in Pasteurized milk, yoghurt and Cheese manufacturing?

Your Questions..

Few and far between: egg in milk

Eggnog - a mixture of milk, eggs, sugar, and cream

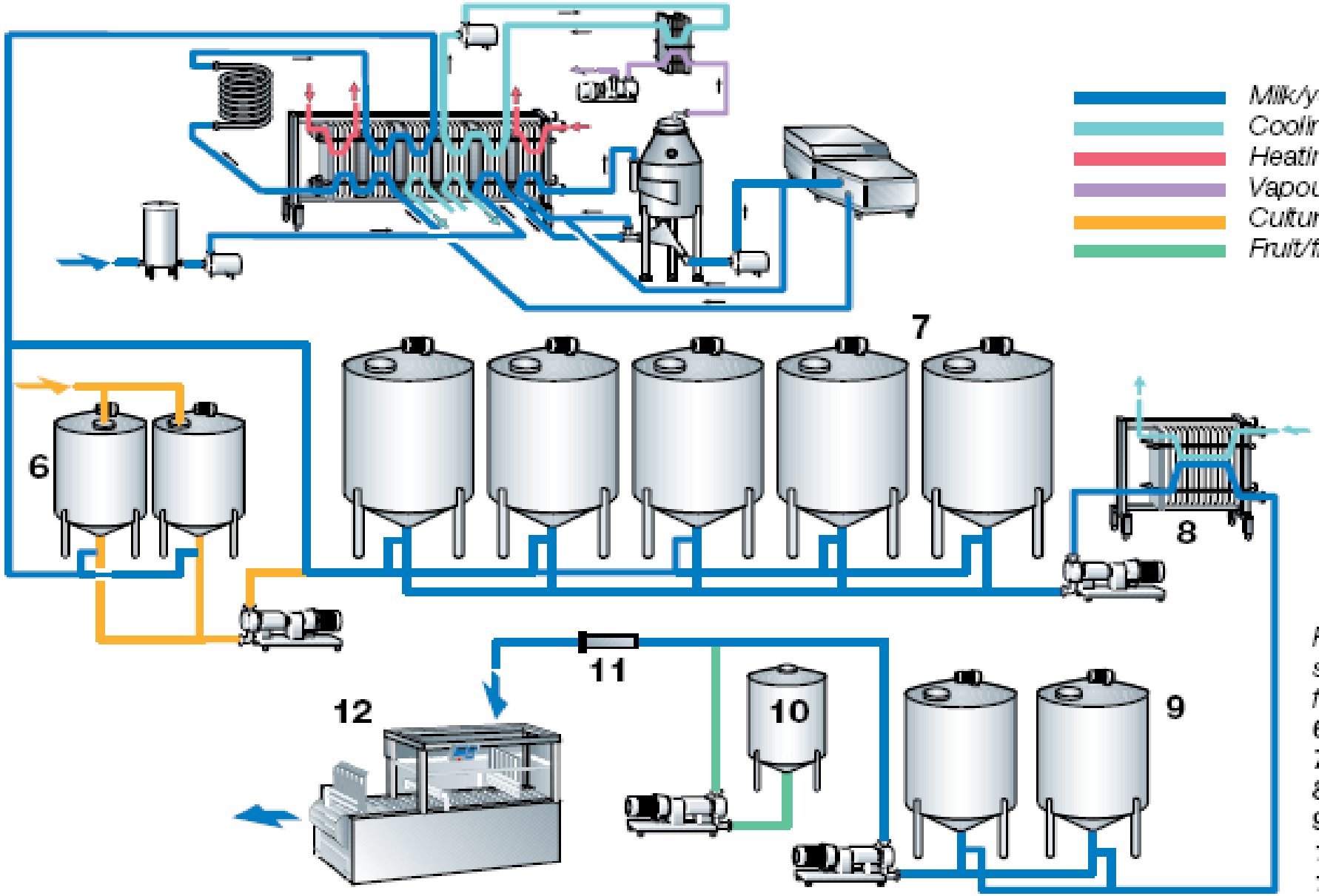
Revision: The CRITICAL ASSET

- ✓ Self assessment and keynote preparation from various sources: Hard and soft copy
- ✓ It might reach you to the wisdom of knowledge and skill transformation

Next… Lecture

- **Dairy Engineering towards Fermented Products Processing**
- **Yogurt Manufacturing**
- **Kefir Mnaufacturing**

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

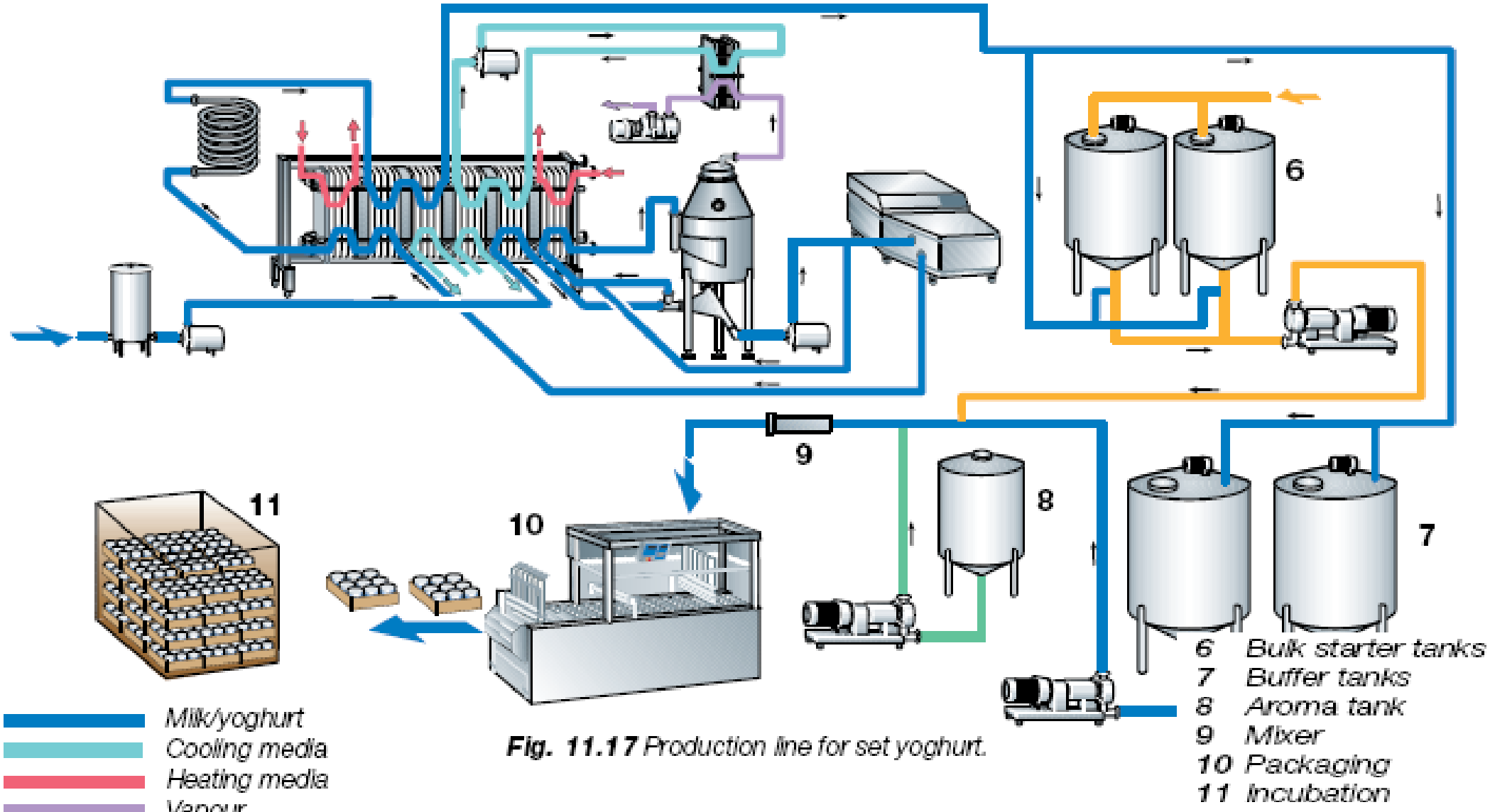


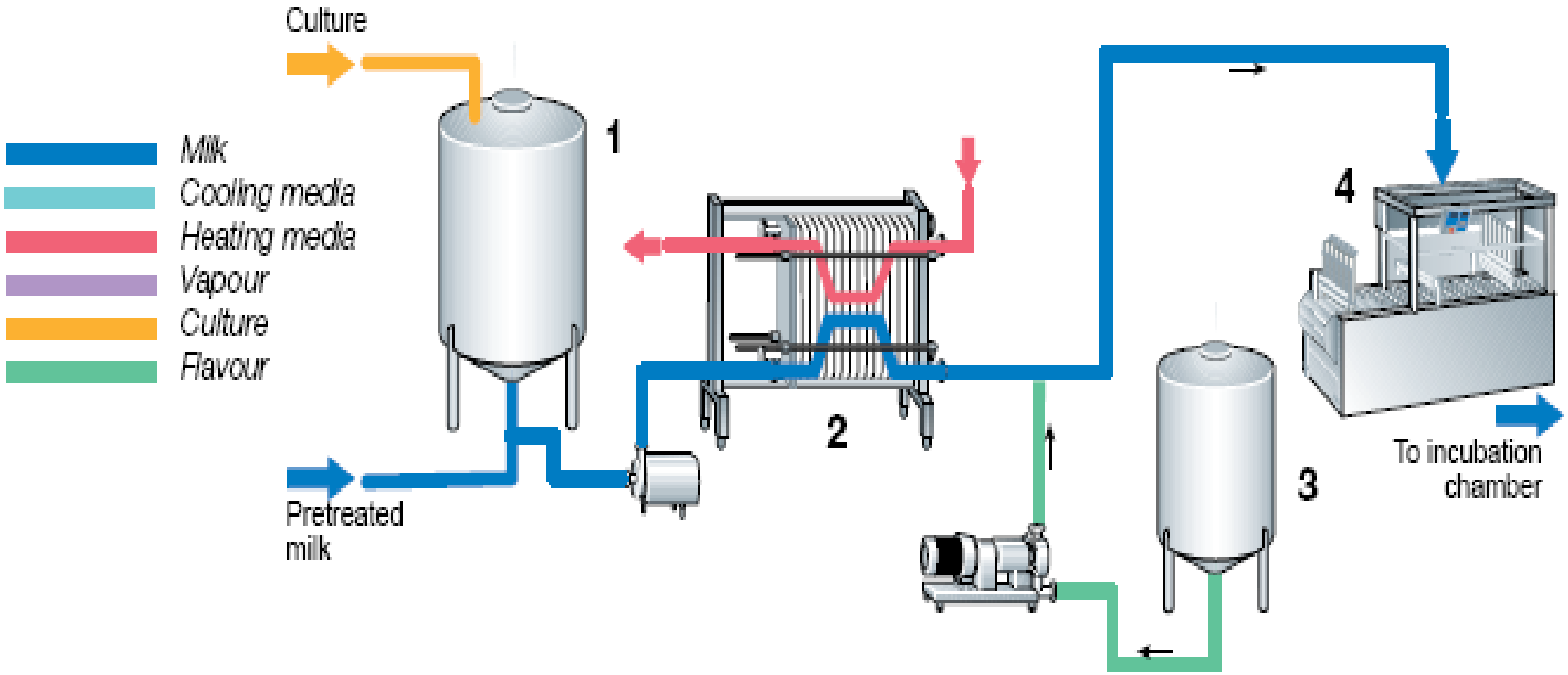
Fig. 11.17 *Production line for set yoghurt.*

An alternative production system

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

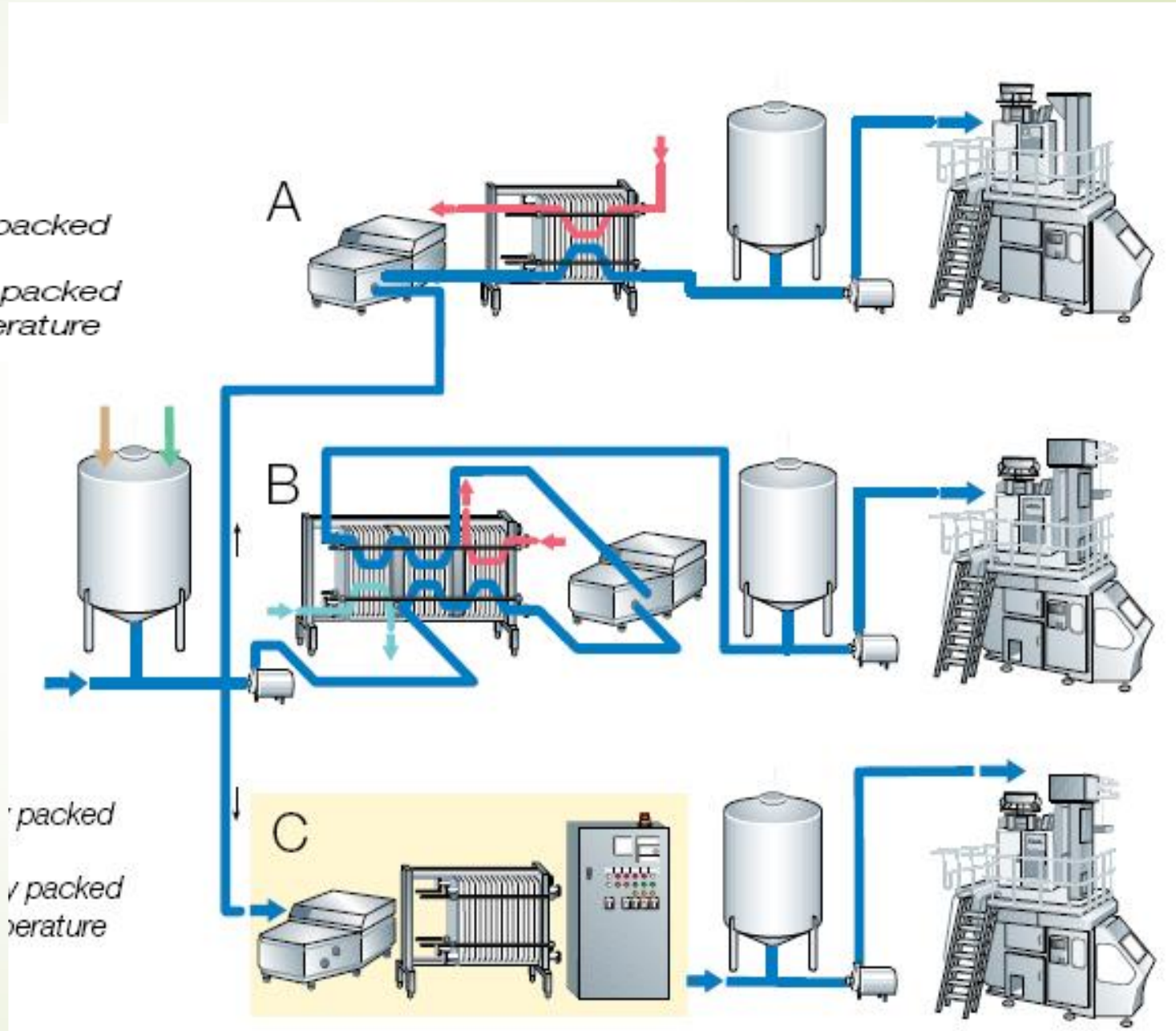
Final Steps in set Yoghurt Production

1 Incubation tank
2 Plate heat exchanger
3 Flavour
4 Packaging

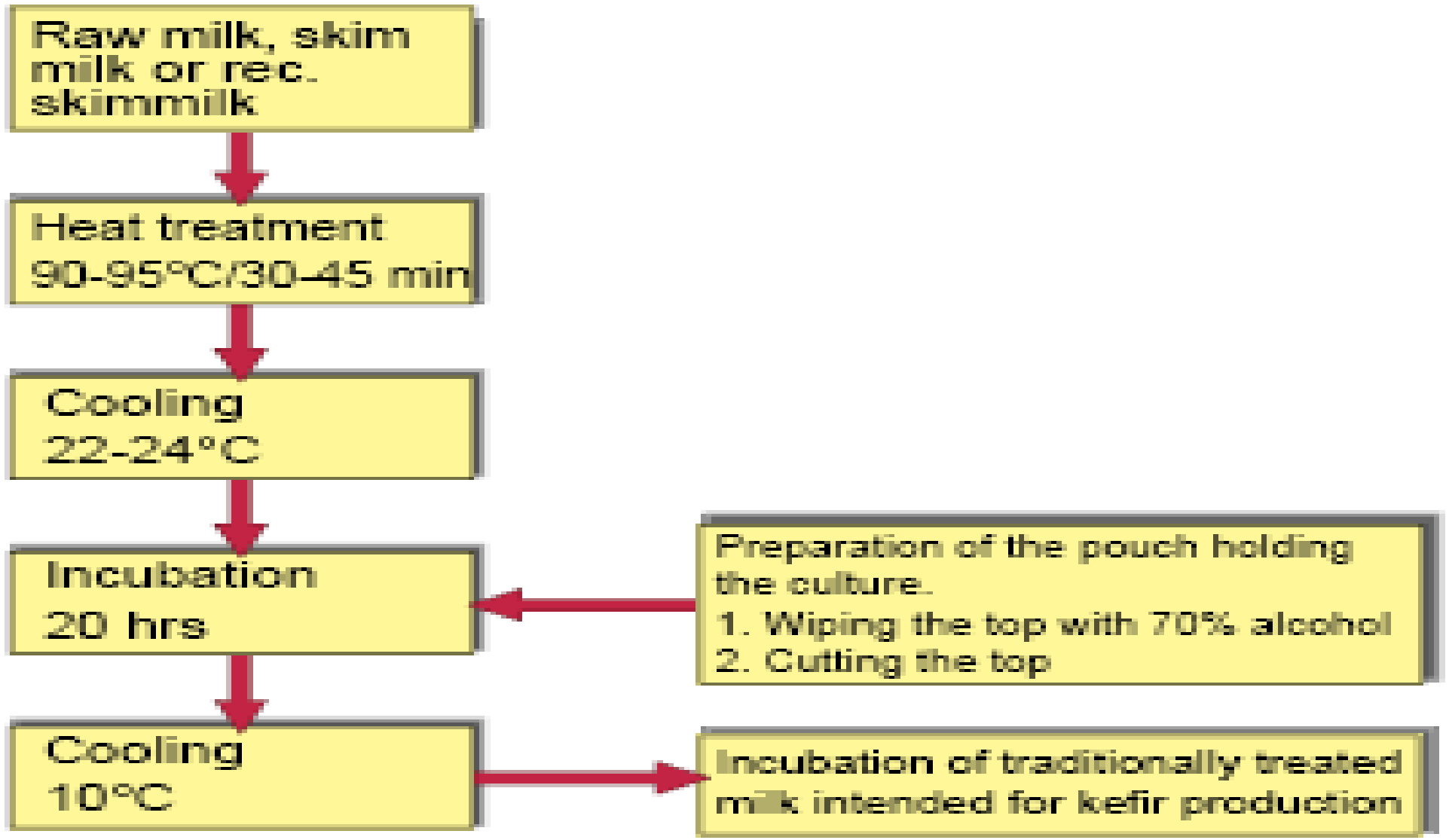


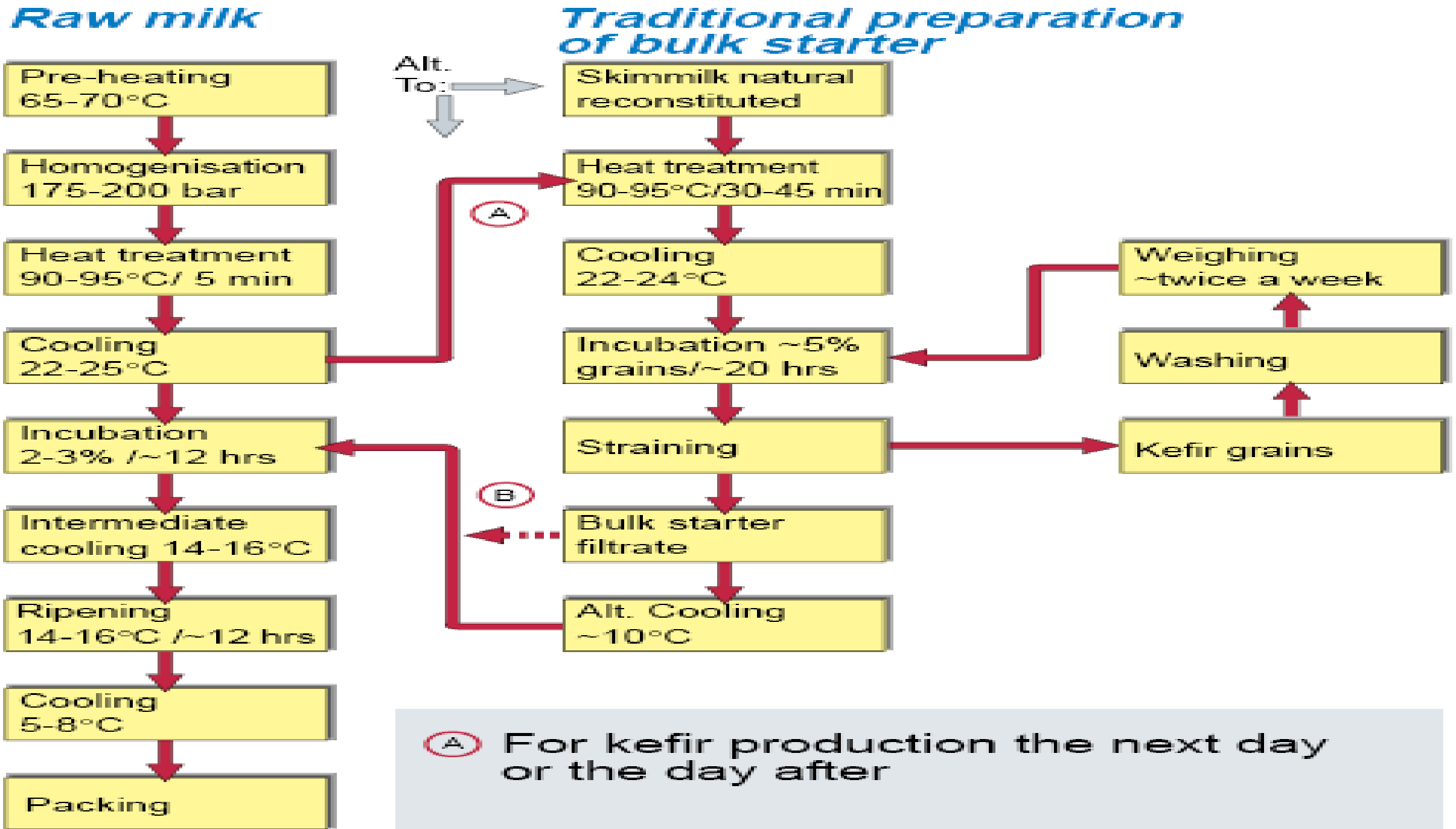
Process Alternatives for Drinking Yogurt

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



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:

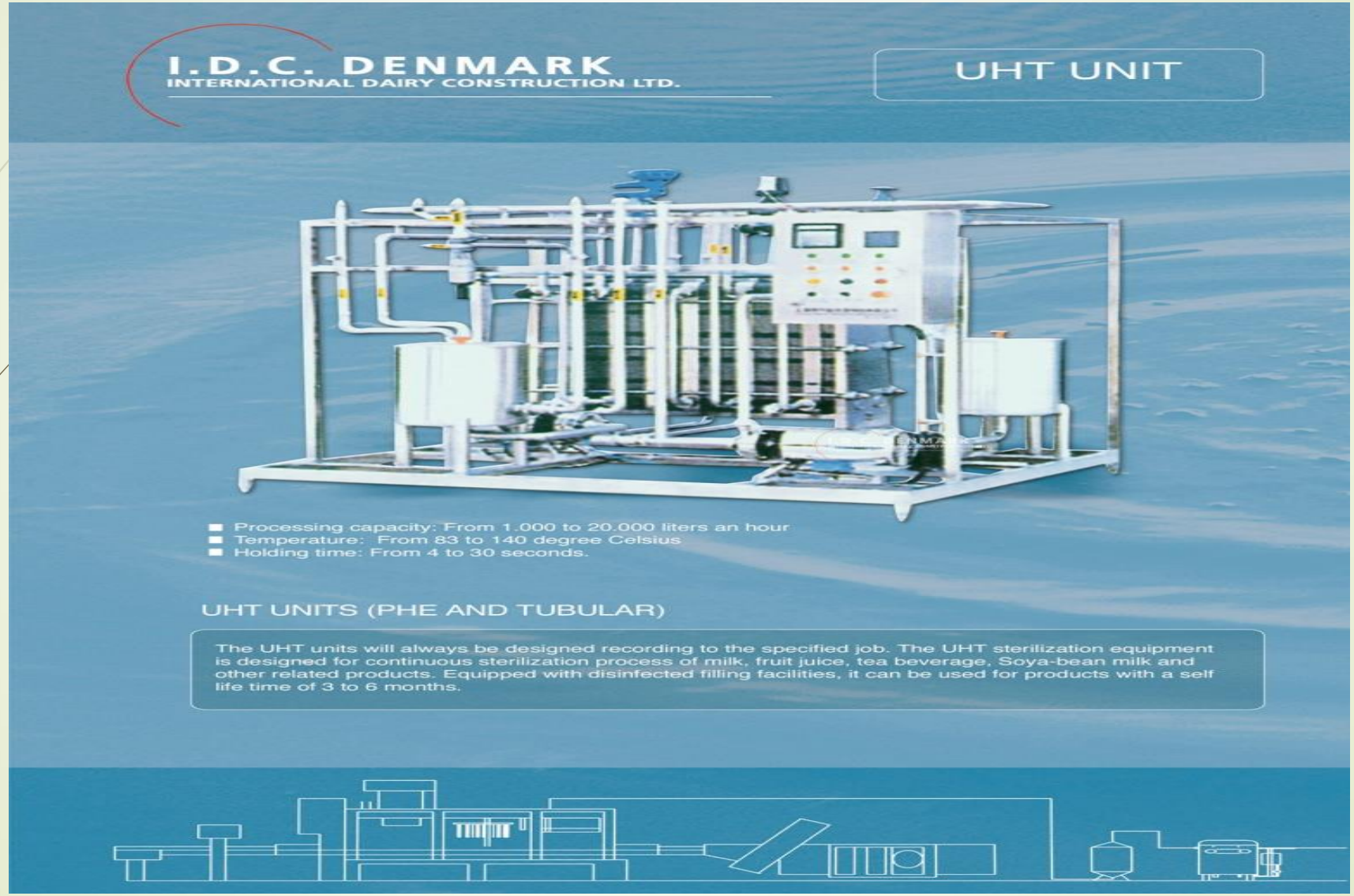
- Fat standardisation (not always practised).
- Homogenisation.
- Pasteurisation and cooling to incubation temperature.
- Inoculation with starter culture (here also called filtrate).
- Incubation in two stages (this, together with the specific culture, is characteristic of kefir).
- Cooling.
- Packing.

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

Succeeding lecture:

Spray drying as part of dairy engineering