SCHOOL OF CHEMICAL AND BIO-ENGINEERING

ADDIS ABABA INSTITUTE OF TECHNOLOGY

ADDIS ABABA UNIVERSITY

Dairy Products Processing Technology

Cheese Processing

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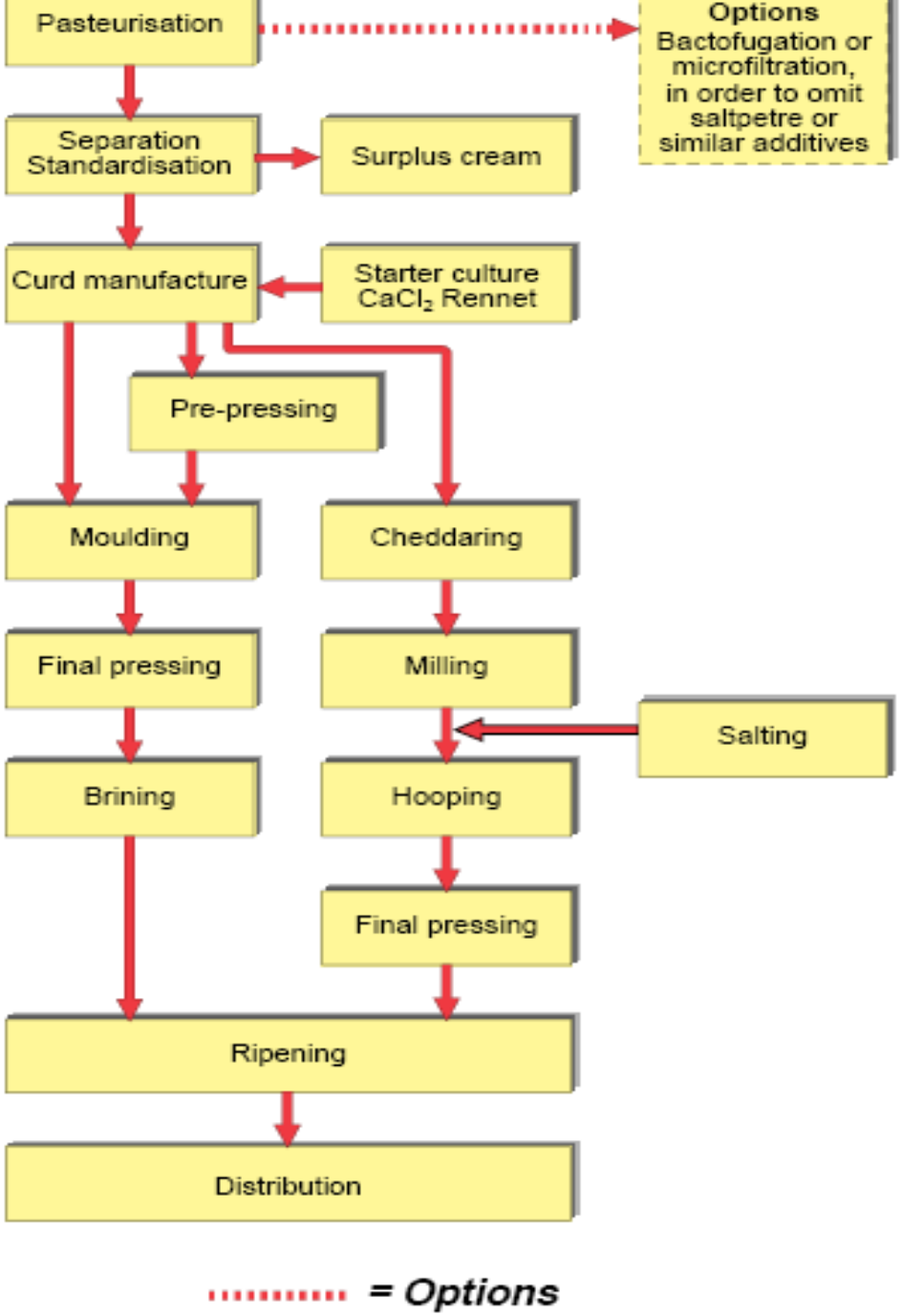
Cheese

Classification of Cheese

- Cheese is made in every country of the world with different varieties
- Despite the number of varieties it can be classified as according to regulation in each country
  - Rennet/natural cheese
  - Fresh/non ripened cheese and ripened cheese
  - Long-life cheese (processed cheese)
  - According to their texture or composition
- Thousands of varieties of cheeses have evolved that are characteristic of various regions of the world.

Cheese Processing Technology

- Cheese is made as a way of preserving the nutrients of milk and increase the bioavailability of the nutrients
- **Cheese is the fresh or ripened product obtained after coagulation and whey separation of milk, cream or partly skimmed milk, buttermilk or a mixture of these products.**
- Cheese has a shelf life from 4-5 days up to 5 years
- Cheese is a concentrated form of milk that contains casein, various percentages of fat, mineral salts (Ca, Fe, P), vitamins & essential amino acids
- Cheese is an essential sources of protein, fat, minerals such as, vitamins & essential amino acids
- Some common cheese making steps was outlined here: ***



- Fat relative to SNF (Casein) = F/SNF (Casein)

- Pasteurisation
  - 70-72°C/15-20 s (not always employed)
  - Cooling to about 30°C = renneting temperature

Options
- Mechanical reduction of bacteria:
  - Bactofugation
  - Microfiltration

From milk to cheese

- In the cheese vat
  - Conditioning of cheese milk
    - Additives:
      - Calcium chloride
      - Saltpetre, if permitted by law
      - Starter bacteria, appropriate to type of cheese
      - Rennet as coagulant
- Coagulum
  - Cutting into grains (curd)
  - Heating, scalding, directly or indirectly, depending on type of cheese
  - Collection of curd for pre-pressing and/or final moulding/pressing, and if required
  - brine salting

  or for cheddar cheese
  - Cheddaring followed by milling, salting, hooping, and pressing
- Formed, pressed, and salted cheese to ripening room storage for required time

Fig. 14.1 *Process flow in production of hard and semi-hard cheese.*

Thermisation

- Moderate Heat Treatment at 65^{o}C for 15 seconds which is often given to Cheese milk

Ingredients for cheese making

- **Major ingredients** in cheese making process involves
- **Milk**: Cow, goat, sheep etc
- **Starter**: Pure culture of LAB (main task: **Develop acid in the curd**)
- **Color**: The recipe and market will determine if coloring materials are used (Bleaching agents to whiten the curd
- **Chemicals**: **$CaCl_2$, ($NaNO_3$ or KNO_3) saltpetre**; recommended for some varieties of cheese to **improve curd quality** and **prevent the growth of organisms (Butyric-acid or coliform bacteria)** which may cause problems during the ripening or maturity of the cheese.
- **Coagulant**: Rennet and juice extract of some fruits and plants (Lemons,*Calotropis procera*,papain,bromelin*)*
- **Salt**

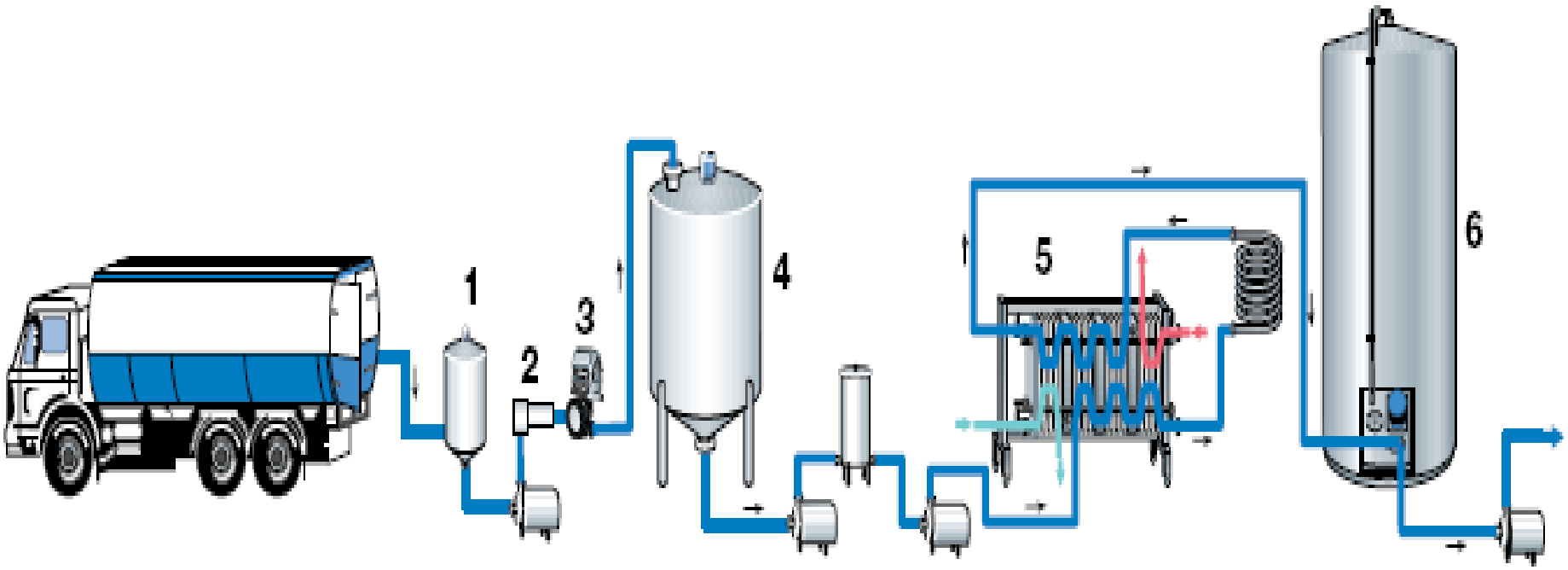


Fig. 14.2 Reception arrangements for cheese milk.

1 Air eliminator
2 Filter
3 Milk meter
4 Intermediate storage tank
5 Thermisation and cooling or cooling only
6 Silo tank

Milk
Heating medium
Cooling medium

Principal cheese making procedures

- Cheese making process is an art by developing cheese making recipe for the manufacture of a specific variety of cheese
- Treatment of Milk
- Additives
- Inoculation and Milk Ripening
- Coagulation
  - enzyme
  - acid
  - heat-acid
- Curd Treatment (cutting the coagulum, heating or cooking the curd
- Whey removal, curd texturing, molding, pressing
- Cheese Ripening

Treatment of Milk for Cheese making

- Cheese milk must first be **clarified**, **separated** and **standardized**.
- The milk may then be subjected to pasteurization (72° C for 16 sec)
- This less severe heat treatment is thought to result in a better final flavour cheese by preserving some of the natural flora.
- **Homogenization is not usually done for most cheese milk**. It disrupts the fat globules and increases the fat surface area where casein particles adsorb.

Additives

- The following may all be added to the cheese milk:

- **Calcium chloride**
- **Nitrates**
- **Color**
- **Hydrogen peroxide**
- **Lipases**

Additives continued…

- **Calcium chloride** is added to replace calcium redistributed during pasteurization.
- Milk coagulation by rennet during cheese making requires an optimum balance among ionic calcium and both soluble insoluble calcium phosphate salts.
- Because calcium phosphates have reverse solubility with respect to temperature, the heat treatment from pasteurization causes the equilibrium to shift towards insoluble forms and depletes both soluble calcium phosphates and ionic calcium. Near normal equilibrium is restored during 24 - 48 hours of cold storage, but cheese makers can't wait that long, so $CaCl_2$ is added to restore ionic calcium and improve rennet ability.
- The calcium assists in coagulation and reduces the amount of rennet required.
- **Sodium or potassium nitrate** is added to the milk to control the undesirable effects of *Clostridium tyrobutyricum* in cheeses such as Edam, Gouda, and Swiss.
- Because milk color varies from season to season, **color** may added to standardize the color of the cheese throughout the year. **Annato, Beta-carotene, and paprika** are used.
- The addition of **hydrogen peroxide** is sometimes used as an alternative treatment for full pasteurization.
- **Lipases**, normally present in raw milk, are inactivated during pasteurization. The addition of kid goat lipases are common **to ensure proper flavor development through fat hydrolysis**.

Inoculation and Milk Ripening

- The basis of cheese making relies on the fermentation of lactose by **lactic acid bacteria** (LAB).
- LAB produce lactic acid which lowers the pH and in turn assists coagulation, promotes syneresis, helps prevent spoilage and pathogenic bacteria from growing, contributes to cheese texture, flavour and keeping quality.
- **LAB** also produce growth factors which encourages the growth of non-starter organisms and **provides lipases** and **proteases** necessary for flavour development during curing.
- After inoculation with the starter culture, the milk is held for 45 to 60 min at 25 to 30° C to ensure the bacteria are active, growing and have developed acidity. This stage is called **ripening the milk** and is done prior to renneting.

Milk Coagulation

- Coagulation is essentially the formation of a gel by destabilizing the casein micelles causing them to aggregate and form a network which partially immobilizes the water and traps the fat globules in the newly formed matrix. This may be accomplished with: enzymes, acid treatment, heat-acid treatment
- **Enzymes**: Chymosin/rennet, is most often used for enzyme coagulation. Rennin can be obtains from milk-fed calves and also be derived by genetic engineering, by conveying genetic material into bacteria). Rennin produces lactic acid which clots milk casein.
- Rennet transforms liquid milk into a gel. While the process is not fully understood, rennet coagulation is thought to take place in two distinct phases, the first of which is regarded as being enzymatic, the second non-enzymatic.
- The first, or primary phase, can be illustrated as:

water

Casein ----------> para casein + glycomacropeptide

rennet

water

k-casein ---------- para k-casein + glycomacropeptide

rennet (insoluble) (soluble)

The second phase is the non-enzymatic precipitation of para casein by calcium ions

Para casein, in association with the **calcium ions**, is thought to produce a **lattice structure** throughout the milk.

Bacteria-Based Processes and Products (…Industrial Biotechnology)

- Dairy products
- Cheese and fermented milk products
- What is Cheese?

- According to legend, cheese was first invented by a shepherd, carrying milk in a pouch made from a sheep's stomach (7000 BC). The **rennet** from the sheep's stomach lining and heat from the sun separated the milk into curds and whey.
- Scientists later discovered that the enzyme rennin (produced in calf stomach lining cells) would coagulate the protein (casein) in milk, forming curds and whey.

- Cheese is made by coagulating milk to give curds which are then separated from the liquid (whey) after which they can be processed and matured to produce a wide variety of cheeses. Milk is coagulated by the addition of rennet.

Rennet

- Rennet : Substance containing rennin, an enzyme having the property of clotting or curdling milk. The enzyme splits kappa-casein, a major milk protein, causing the milk to clot.
- The active ingredient of rennet is the enzyme, chymosin (rennin)
- The usual source of rennet is the stomach of slaughtered newly-born calves. Especially from the inner lining of the fourth stomach (*abomasum*) of milk-fed calves.
- It is usually prepared by drying, cutting and soaking the tissues in warm, slightly salted water and filter the supernatant resulting liquid.
- Previously extract of rennet is made in large amount and sold commercially.

Disadvantage of using *Animal Rennet*

- Milk-fed calves are slaughtered so their stomachs can be used to supply rennin.(slaughtering of calves)
- The numbers and ages of calves sent to slaughter houses vary, so the supply and quality of rennin vary as well.
- Weak activity and low purity
- Difficulty to get concentrated rennet (88-94%)
- Lack of availability of cheaper and pure form of rennet
- **Doesn’t creates an endless supply of the enzyme chymosin.**

New Approaches of Food Biotechnology -Rennet Production

- Before biotechnology, most of the enzyme rennet, used to make cheese, came from the lining of calves' stomachs.
- The use of biotechnology has enabled researchers to remove the specific gene that produces rennet and reproduce it in bacteria.
- Using , through Genetic engineering, the gene from the calf stomach cell DNA which makes the cell produce the enzyme, rennin, is removed and inserted into a DNA of a bacteria or yeast cell. The microorganism (bacteria) then can make an exact copy of the calf enzyme.
- This allows the production of rennet through a fermentation process, eliminating the need for extracts from calves' stomachs.

Chymosin

- Cheese makers use a biotech-manufactured enzyme called chymosin.
- Chymosin is a manmade copy of natural rennin;

which has been isolated from a genetically-altered microorganism utilizing biotechnology.

- Brand names given for this kind of rennet include Chy-Max, Chymostar Classic, Maxiren and Chymogen produced by different companies, which genetically engineered the bacteria to produce the enzyme (Chymosin created in 1990)

Genetically Engineered Bacterium (Classical Biotechnology)

- The use of a living organism (a bacterium) to move genes from one organism to the next. The bacterium acts as a truck, hauling changes from site A to site B. Differs from recombinant DNA by using a living organism to transfer information.

- In recent times, the genes responsible for rennet production have been transferred from calf cells to bacterial cells. The **daughter cells** of these bacteria produce rennin that is identical to that of calves.

Could vegetarians eat cheese made from this cloned *chymosin*?

- ☑ Vegetarian Societies have endorsed cheese made with genetically engineered *chymosin* as vegan.
- ☑ Reasoning include only copies of an animal gene were being used in the manufacture of the cheese no true animal products were present.
- ☑ These cheeses have also been approved for Muslims and Jews, (***Vegetarian Cheeses***)
- ☑ In England the cheese using cloned rennet is labeled: Produced using gene technology and so free from animal rennet!

Alternative Rennet's

- Plant extract coagulants which have coagulating properties.
- Extracts from papaya (papain), pineapple (bromeline), castor oil seeds, the latex of fig tree and the plant *Calotropis procera* which grow abundantly in many parts of Africa (in Ethiopia, Afar and North Showa).
- **Fig tree** bark, **thistles**, and **mallow**.
- Commercial vegetable rennet's usually contain rennet from the **mold** *Mucor miehei also used*.
- Rennet from thistle or ***cynara*** is used in traditional cheese production throughout the **Mediterranean**.

Acid Treatment

- **Lowering the pH** of the milk results in casein micelle destabilization or aggregation. Acid curd is more fragile than rennet curd due to the loss of calcium.
- Acid coagulation can be achieved naturally with the starter culture. Acid coagulated fresh cheeses may include Cottage cheese and Cream cheese.
- **Heat-Acid Treatment**: Heat causes denaturation of the whey proteins.
- The denatured proteins then interact with the caseins. With the addition of acid, the caseins precipitate with the whey proteins.
- In rennet coagulation, only 76-78% of the protein is recovered, while in **heat-acid coagulation**, 90% of protein can be recovered. Examples of cheeses made by this method include **Paneer**, **Ricotta** and **Queso Blanco**.

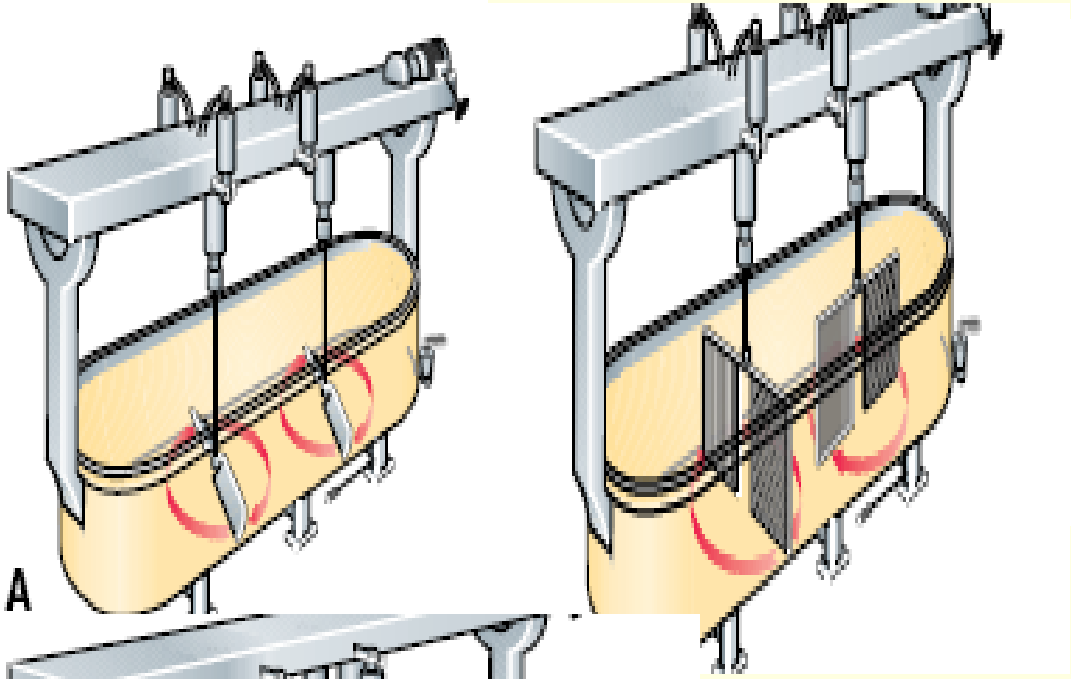
Curd Treatment

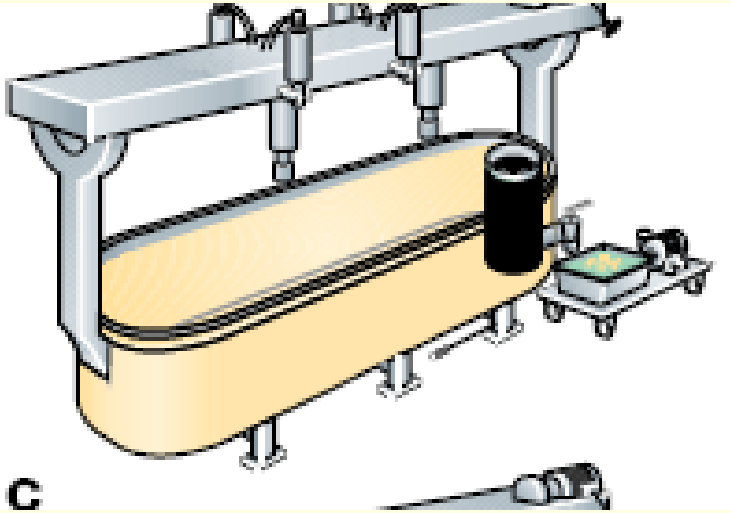
- After the milk has gel has been allowed to reach the desired firmness, it is carefully **cut** into small pieces with knife blades or wires. This shortens the distance and increases the available area for whey to be released.
- The curd pieces immediately begin to shrink and expel the **greenish liquid** called **whey**. This **syneresis** process is further driven by a cooking stage. The increase in temperature causes the protein matrix to shrink due to increased hydrophobic interactions, and also increases the rate of fermentation of lactose to lactic acid. The increased acidity also contributes to shrinkage of the curd particles.
- The final moisture content is dependant on the time and temperature of the cook stage. This is important to monitor carefully because the final moisture content of the curd determines the residual amount of fermentable lactose and thus the final pH of the cheese after curing.

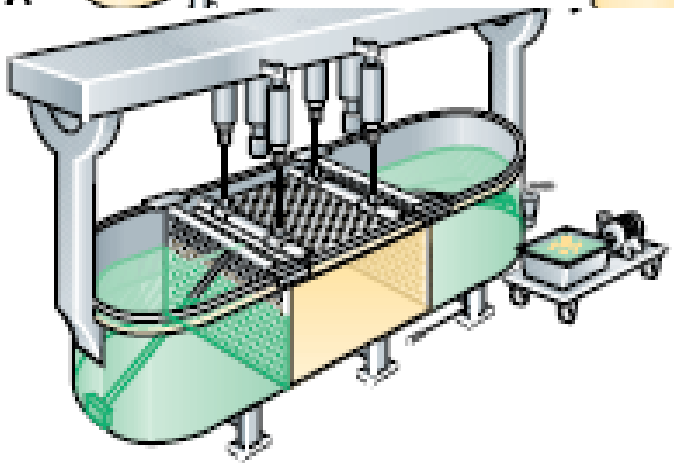
Cont'd

- When the curds have reached the desired moisture and acidity they are **separated from the whey**. The whey may be removed from the top or drained by gravity. The curd-whey mixture may also be placed in moulds for draining.
- Some cheese varieties, such as Colby, Gouda, and Brine Brick include a curd washing which increases the moisture content, reduces the lactose content and final acidity, decreases firmness, and increases openness of texture.
- Curd handling from this point on is very specific for each cheese variety.
- Salting may be achieved through brine as with Gouda, surface salt as with Feta, or vat salt as with Cheddar. To achieve the characteristics of Cheddar, a cheddaring stage (curd manipulation), milling (cut into shreds), and pressing at high pressure are crucial

Cheese making modes/Curd production







A Vat during stirring
B Vat during cutting
C Vat during whey drainage
D Vat during pressing

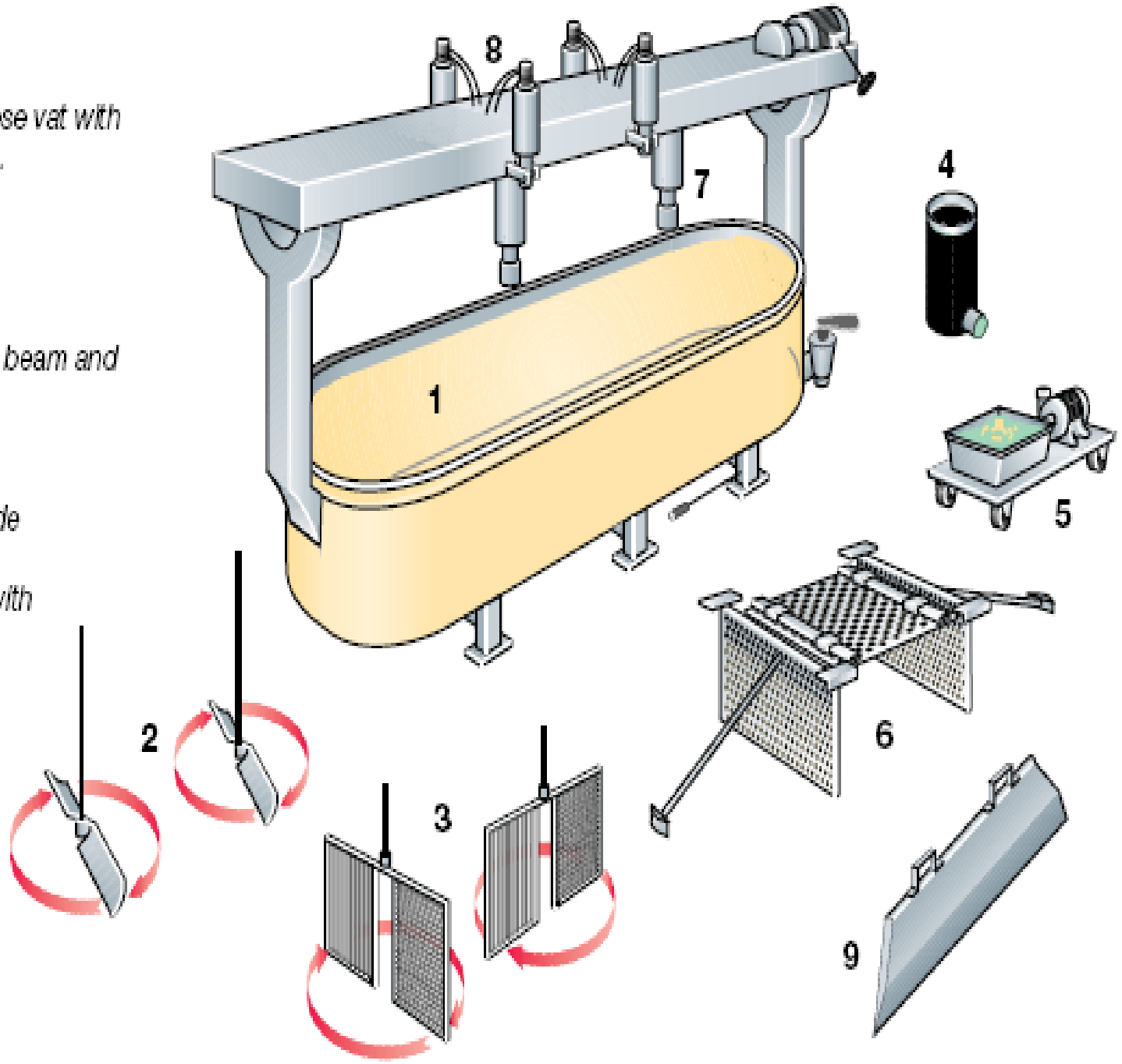


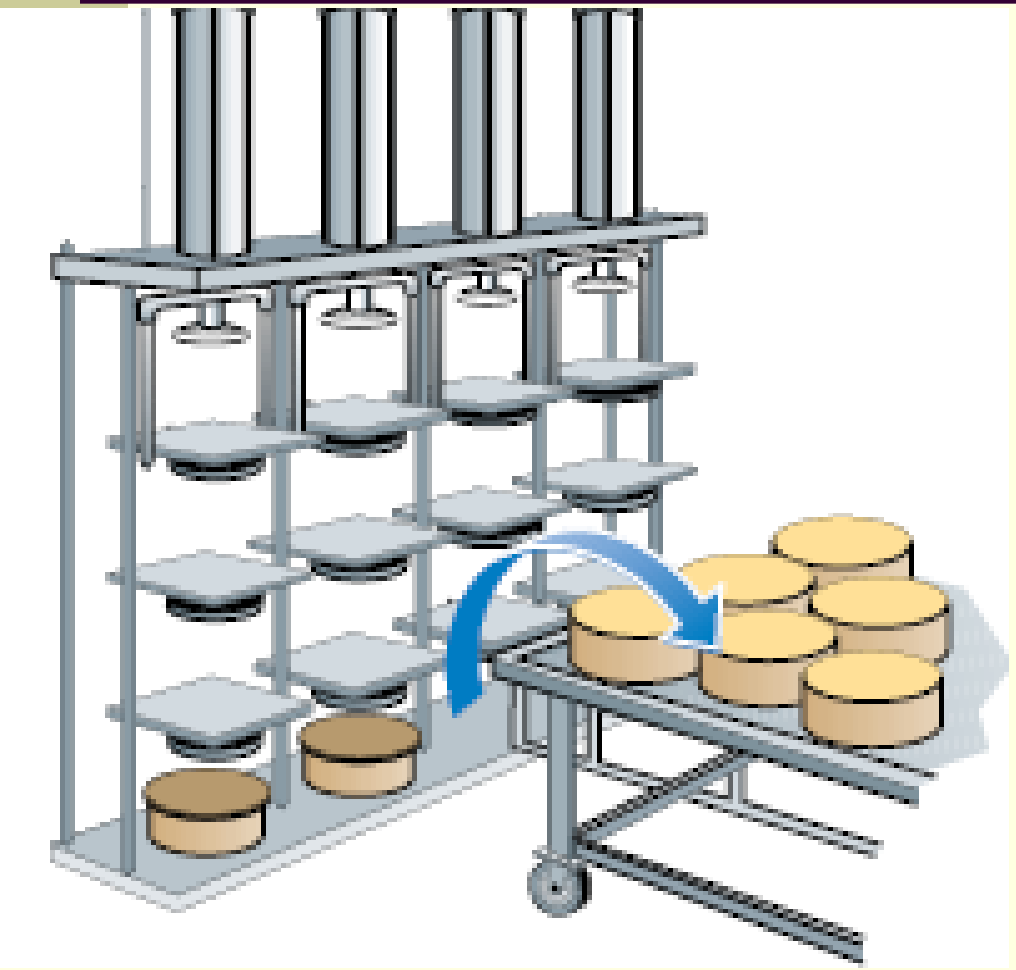
Fig. 14.9 *Conventional cheese vat with tools for cheese manufacture.*

A Vat during stirring
B Vat during cutting
C Vat during whey drainage
D Vat during pressing
1 Jacketed cheese vat with beam and drive motor for tools
2 Stirring tool
3 Cutting tool
4 Strainer to be placed inside the vat at the outlet
5 Whey pump on a trolley with a shallow container
6 Pre-pressing plates for round-eyed cheese production
7 Support for tools
8 Hydraulic cylinders for pre-pressing equipment
9 Cheese knife

Other operations in cheese processing

- Brining (30% salt)
- Moulding the curd
- Pressing: Mechanical or Pneumatic cheese press
- Removal cheese from the mould
- Storage and Waxing
- **Ripening**: the time between curd precipitation and completion of texture, flavor and color development in cheese. Lactose is fermented, fat is hydrolyzed and protein goes through hydrolysis to amino acids

Vertical Pressing Unit with Pneumatically operated pressing plates



Deep Brining System

Chemistry of Cheese Ripening/Aging

- During ripening, degradation of lactose, proteins and fat are carried out by ripening agents. **The ripening agents in cheese are**:
- Bacteria and enzymes of the milk
- Lactic culture
- Rennet
- Lipases
- Added moulds or yeasts
- Environmental contaminants

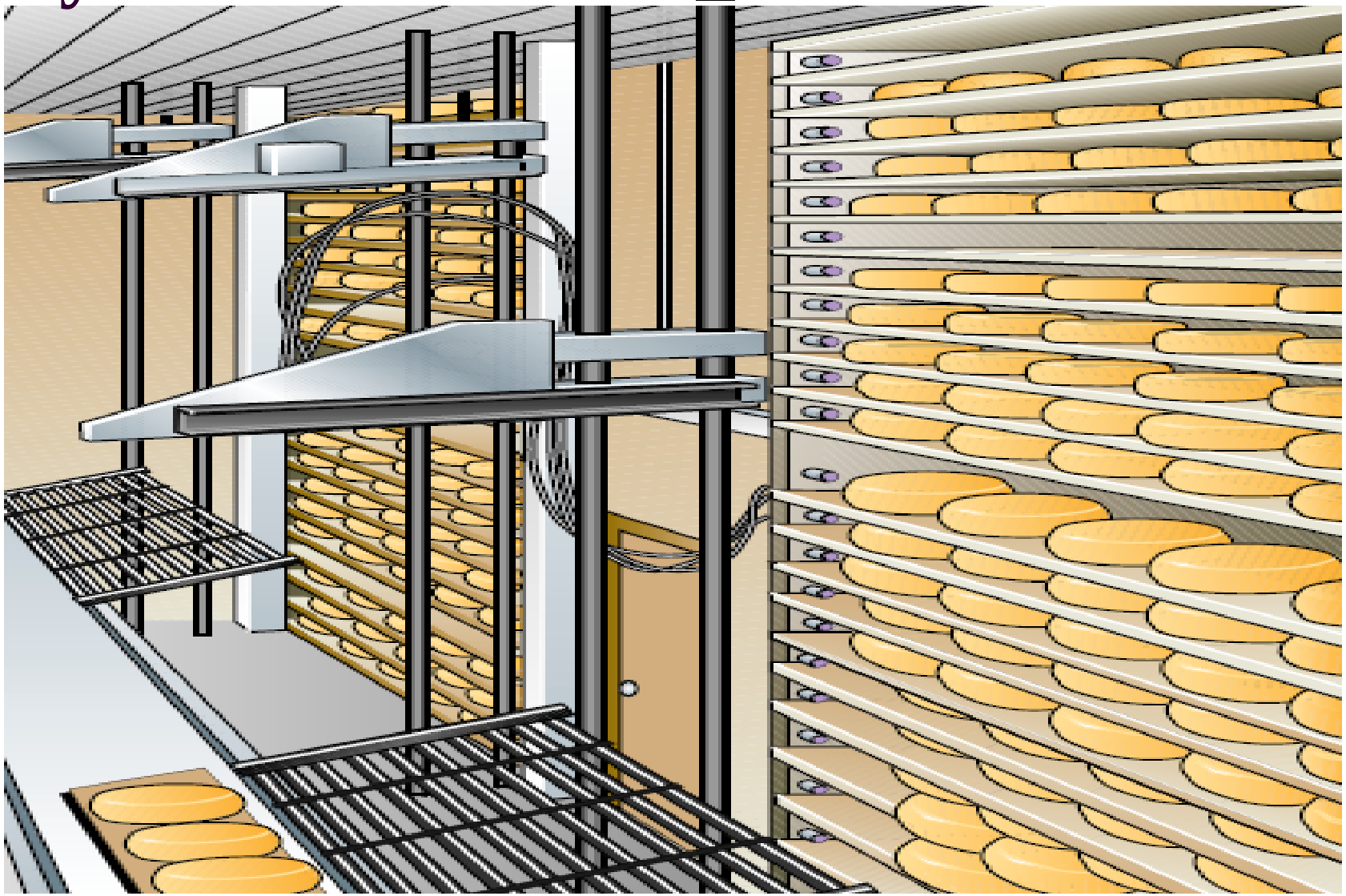
➢ Thus the microbiological content of the curd, the biochemical composition of the curd, as well as temperature and humidity affect the final product.

➢ This final stage varies from weeks to years according to the cheese variety.

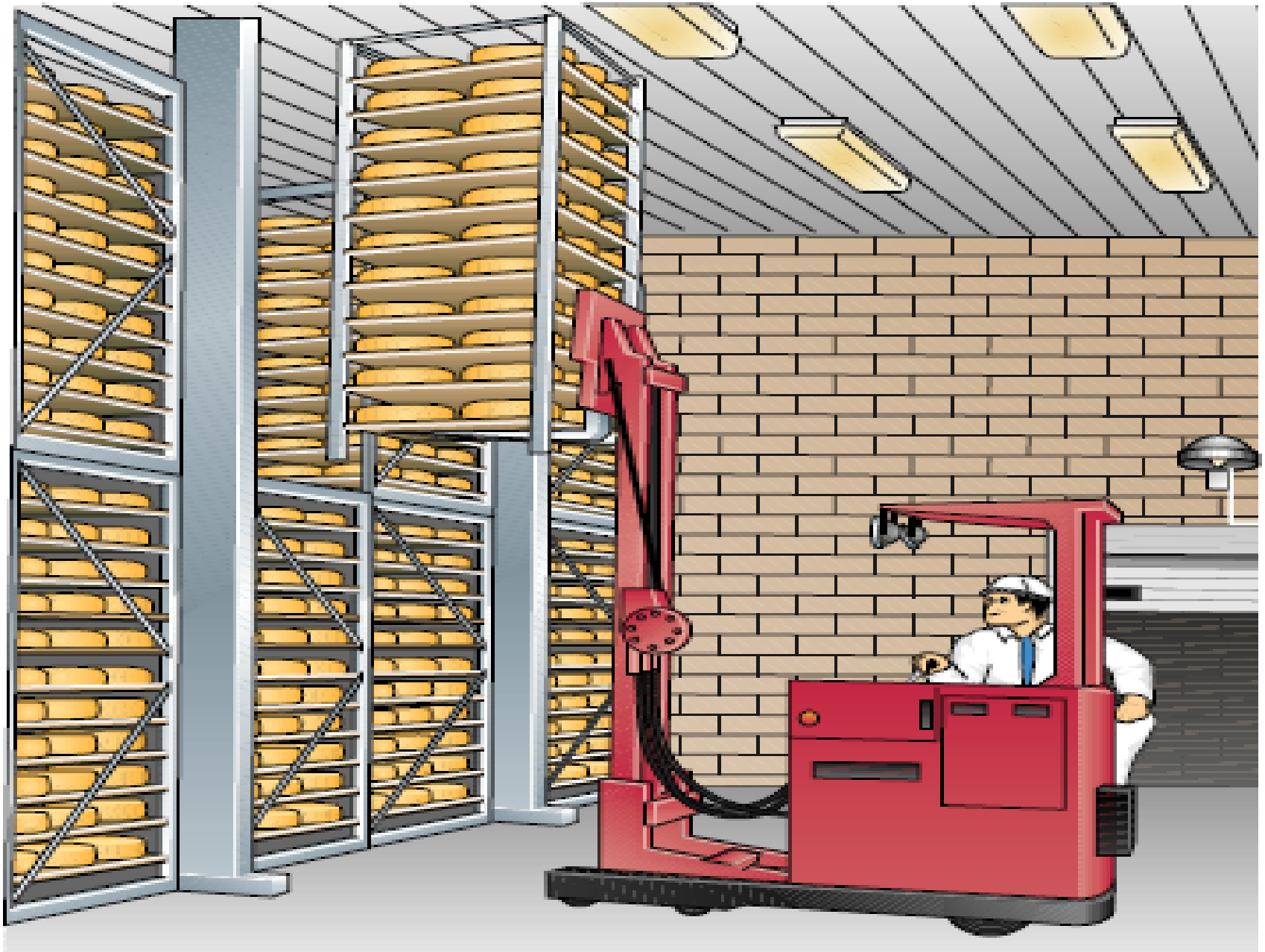
Cheese Ripening and Storage

- Except for fresh cheese, the curd is ripened, or matured, at various temperatures and times until the characteristic flavor, body and texture profile is achieved.
- ***Ripening*** may require 2-12 months and may be the result of bacterial, mold or yeast activity. In that time, *lactose* is fermented by lactose to lactic acid, *fat* is hydrolyzed by lipase and *protein* undergoes some proteolysis to amino acids.
- Cheese ripened by bacteria (the holes or eye formation in Swiss cheese is evidence of gas-producing bacteria that exist throughout the interior of the cheese
- Cheeses, such as **Camembert** and **Brie** are ripened by ***mold*** which is sprayed onto the surface of the cheese
- ***Blue cheese*** which is inoculated with ***Penicillium roqueforti***

Mechanized cheese storage. Humidified air is blown via the plastic nozzles at each layer of cheese



Cheese storage using pallets



Cheese Processing

- Flow sheet of cheese processing and **cheese chemistry** (metabolism of carbohydrate and lactic acid, changes in protein and lipids)
- Process line for cheese processing: Unit operations
- **Cheese yield** ~ (**2.3 x fat%) + 1.4**; in (kg/100 kg milk)

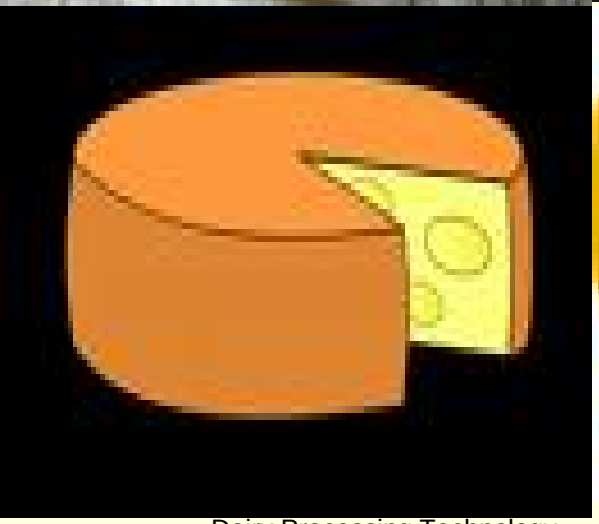
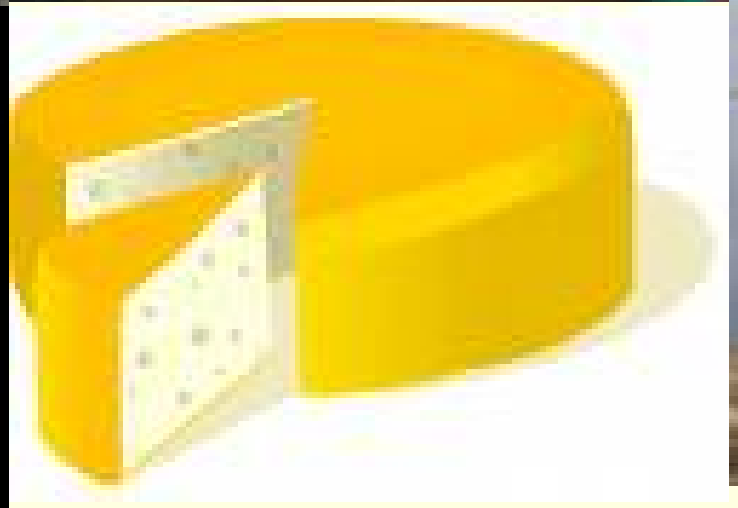
  Therefore, with milk containing 4% fat the expected yield would be:

  (2.3 x 4) + 1.4 = 10.6 kg/100 kg milk
- Causes of cheese spoilage
- Utilization of Ethiopian beeswax for cheese packaging (Thesis)
- Adopt appropriate cheese processing technologies to **Pastoral** and **Agro-pastoral** areas of Ethiopia (Thesis thematic area)
- Scale up of traditional cheese processing into Industrial level

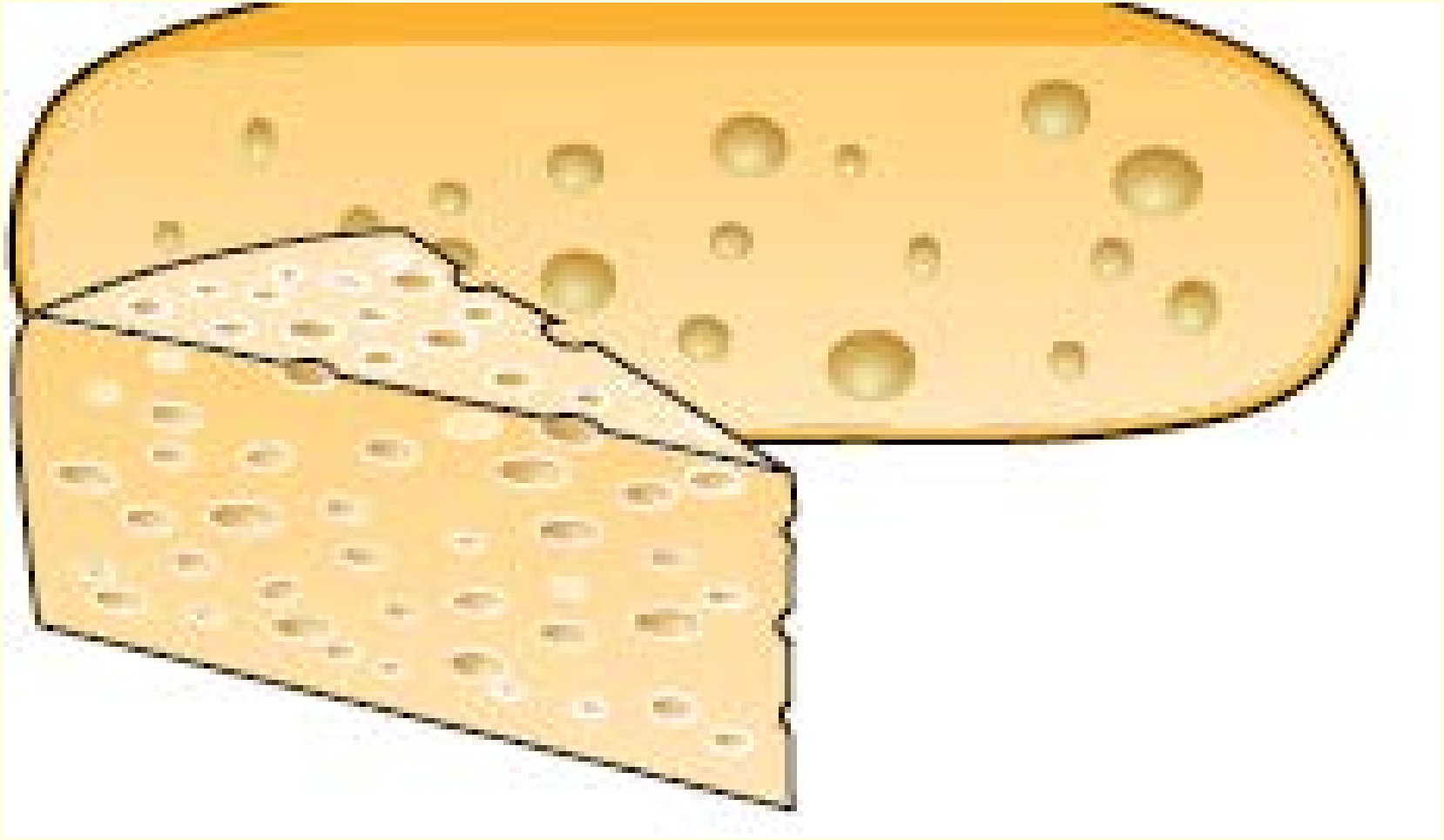
Cheese Processing Industry

Varieties of Cheese…
Let us Produce it in Ethiopia




Cheese with round eyes



Ice cream Production

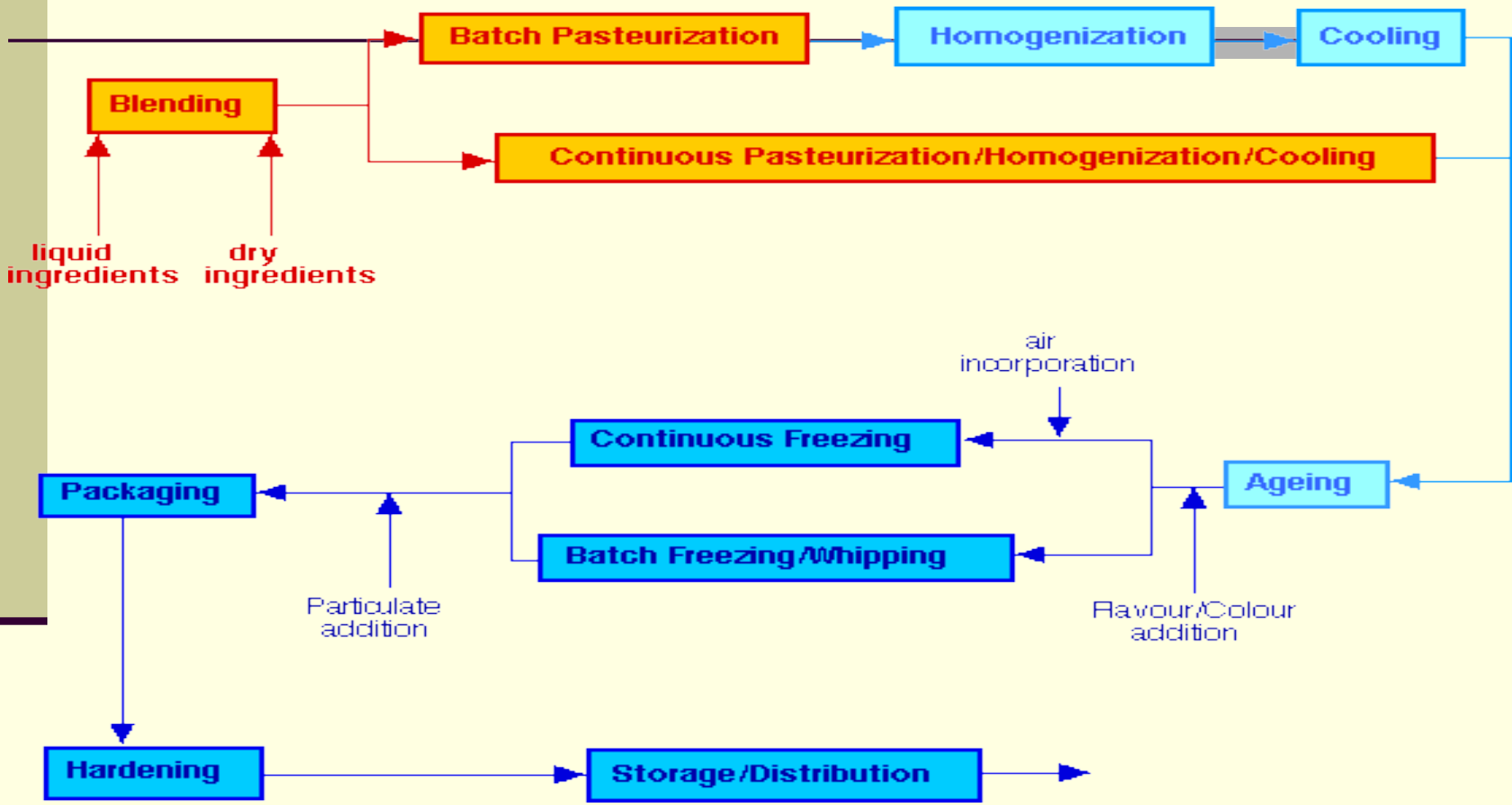
- It is produced by freezing, while stirring a pasteurized mix consisting of one or more of the optional dairy ingredients
- The dairy ingredients for ice cream includes : cream, milk, skim milk, sweet cream butter milk, sweetened condensed milk, Milk fat, SNF
- Other typical ingredients: Colors, emulsifiers, flavors, stabilizers and sweeteners
- The most important task in ice cream processing is blending by accurate proportion

Ice-cream manufacturing

Basic steps

- Blending of the mix ingredients
- Pasteurization
- Homogenization
- Aging the mix
- Freezing
- Packaging
- Hardening

Process flow diagram for ice cream manufacture



Blending

- First the ingredients are selected based on the desired formulation and the calculation of the recipe
- The ingredients are weighed and blended together to produce "**ice cream mix**“
- Blending requires rapid agitation to incorporate powders, and often high speed blenders are used

✓ **% Overrun = (Vic-Vmix)*100/ Vmix**

➢ E.g If a 1-gallon container of ice cream contains an equal measure of ice cream mix and air, it has 1005 overrun. **Overrun may range from 60% to greater than 100%**

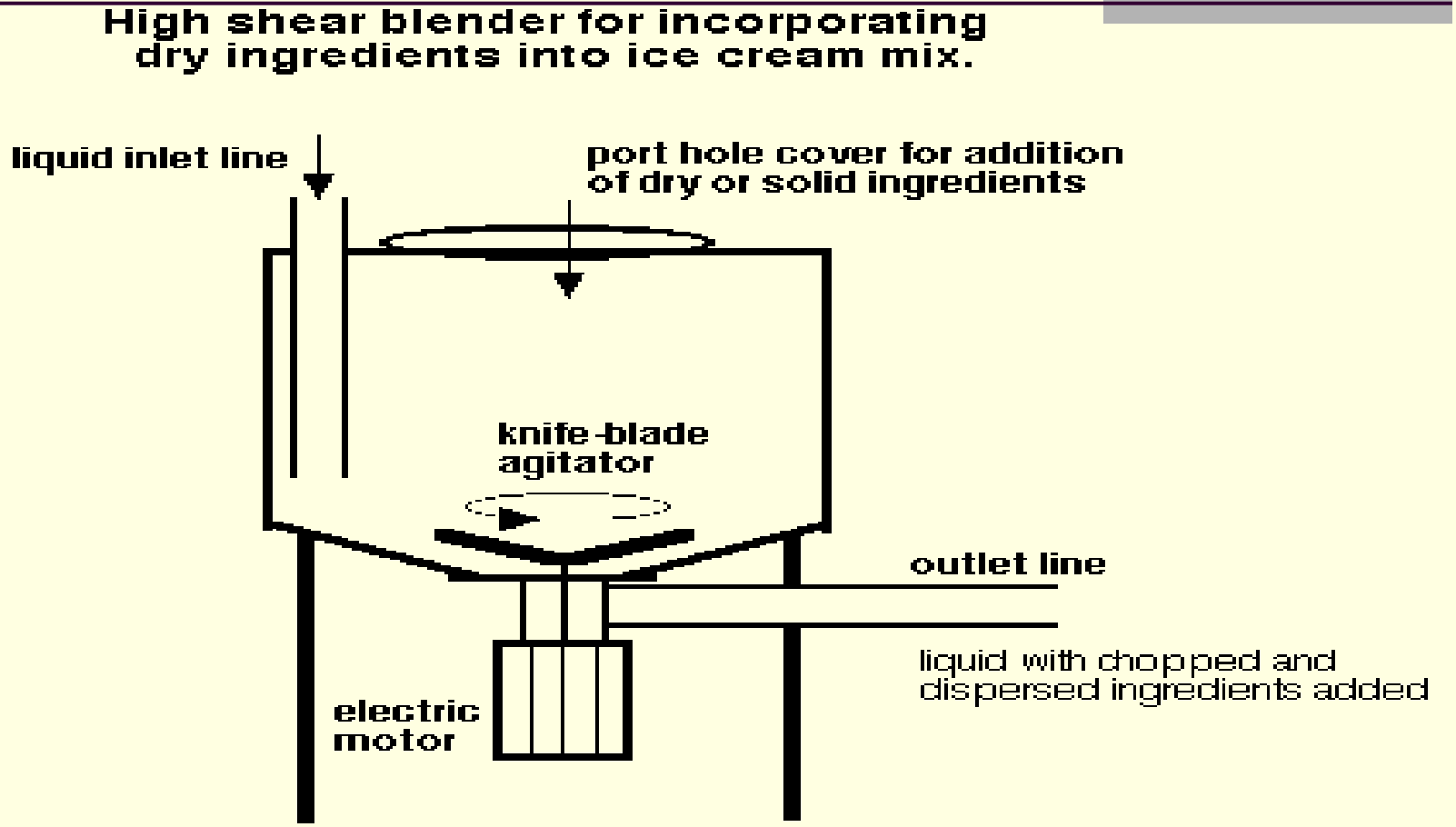
Table 19.1

Typical ice cream formulas

Type of ice cream	Fat % wt	MSNF % wt	Sugar % wt	E/S % wt	Water % wt	Overrun % vol
Dessert ice	15	10	15	0.3	59.7	110
Ice cream	10	11	14	0.4	64.6	100
Milk ice	4	12	13	0.6	70.4	85
Sherbet	2	4	22	0.4	71.6	50
Water ice	0	0	22	0.2	77.8	0

Fat: Milk, cream, butter or vegetable fat
Water: May include flavouring or colouring matter
MSNF: Milk solids-non-fat (protein, salts, lactose)
Sugar: Liquid or solid sucrose (10% of sugar may be glucose or non-sugar sweetener)
E/S: Emulsifier and stabiliser, e.g. monoglycerides, gelatin, alginate
Overrun: Amount of air in product
Other ingredients: Egg, fruit and chocolate pieces may be added during processing.

Blender


High shear blender for incorporating dry ingredients into ice cream mix.
liquid inlet line
port hole cover for addition of dry or solid ingredients
knife-blade agitator
outlet line
liquid with chopped and dispersed ingredients added
electric motor

Pasteurization

The mix is then **pasteurized**.

- Pasteurization is the biological control point in the system, designed for the destruction of pathogenic bacteria.
- In addition to this very important function, pasteurization also reduces the number of spoilage organisms such as psychrotrophs, and helps to hydrate some of the components (proteins, stabilizers).
- 69° C/30 min. 80° C/25s HTST

Homogenization

- The mix is also **homogenized** which forms the fat emulsion by breaking down or reducing the size of the fat globules found in milk or cream to less than 1 µ m.
- **Two stage homogenization** is usually preferred for ice cream mix. A pressure of 2000 - 2500 psi on the first stage and 500 - 1000 psi on the second stage
- Homogenization provides the following functions in ice cream manufacture:
- Reduces size of fat globules
- Increases surface area
- Homogenization of the mix should take place at the pasteurizing temperature

Ageing

- The mix is then **aged** for at least 4h
- Aging allows time for the fat to cool down and crystallize, and for the proteins and polysaccharides to fully hydrate.
- **Aging provides the following functions:**

-Improves whipping qualities of mix and body and texture of ice cream

- Aging is performed in insulated or refrigerated storage tanks, silos, etc. Mix temperature should be maintained as low as possible without freezing, at or below 5 ^{0}C.

Freezing and Hardening

- The mix then enters the **dynamic freezing process** which both freezes a portion of the water and whips air into the frozen mix.
- Mix is pumped through this freezer and is drawn off the other end in a matter of 30 seconds, (or 10 to 15 minutes in the case of batch freezers) with about 50% of its water frozen.
- There are rotating blades inside the barrel that keep the ice scraped off the surface of the freezer and also dashers inside the machine which help to whip the mix and incorporate air.
- Ice cream contains a considerable quantity of air, up to half of its volume. This gives the product its characteristic lightness. Without air, ice cream would be similar to a frozen ice cube. The air content is termed its overrun, which can be calculated mathematically.

Hardening and Packaging

- After the particulates have been added, the ice cream is packaged and is placed into a blast freezer

at -30° to -40° C

- Below about -25° C, ice cream is stable for indefinite periods without danger of ice crystal growth; however, above this temperature, ice crystal growth is possible and the rate of crystal growth is dependant upon the temperature of storage. This limits the shelf life of the ice cream.
- Package type, should not slow down heat transfer

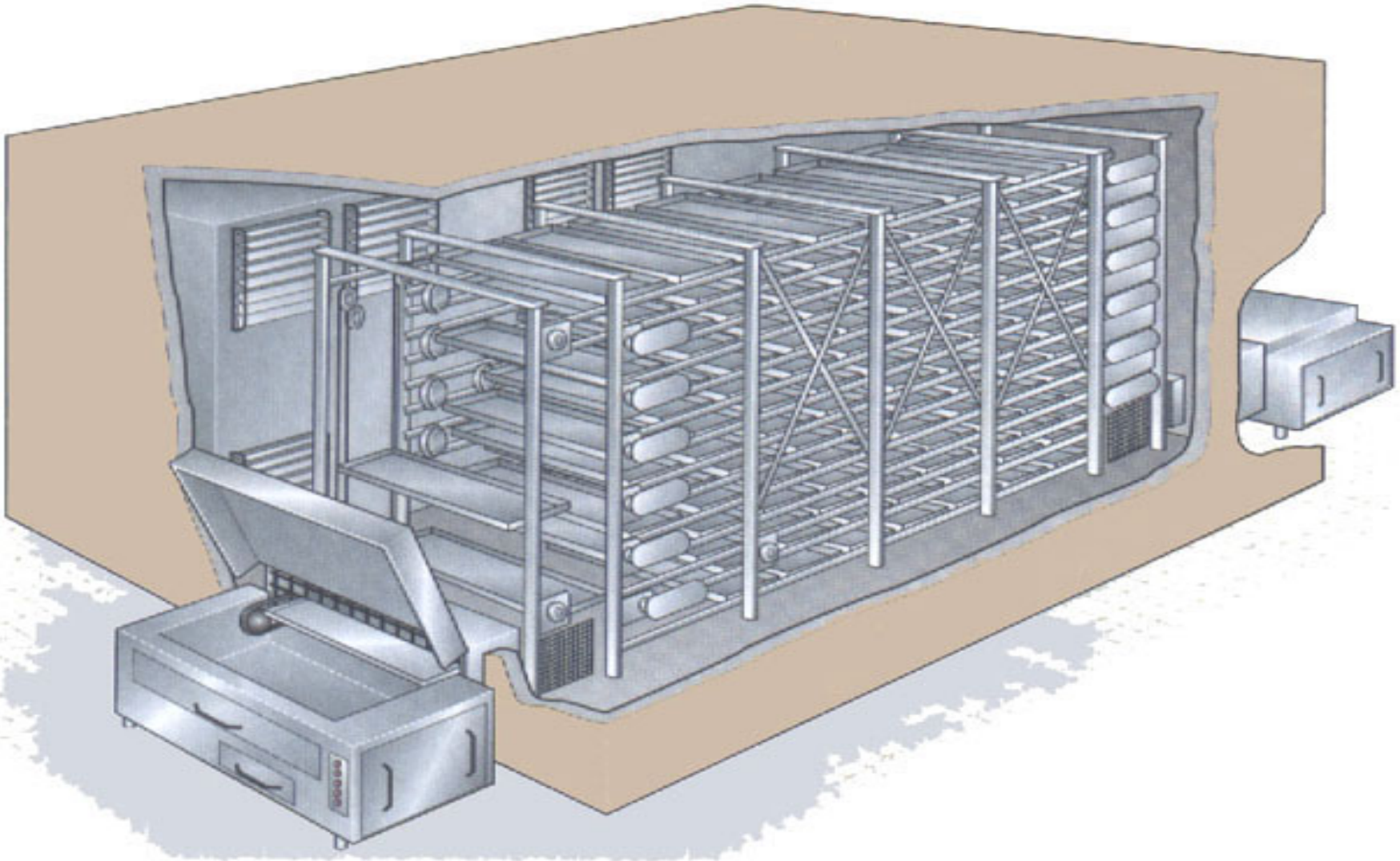


Fig. 19.8 Hardening tunnel.

Summary

- The ice cream mix is subjected to pasteurization, homogenization, cooling, holding (for aging) and quick freezing, packaging of the ice cream and store at -29 ^{0}C
- Slow freezing creates larger ice crystal
- Air is incorporated into an ice cream mixture by agitation
- Ice cream contains not less than 10 % milk fat, nor less than 10% MSNF

Summary

Percent milks	minimum % MSNF
10	10
11	9
12	8
13	7
14	6

- **Ice milk** contains *less* fat and *more* MSNF
- **Deluxe ice cream** contains *more* milk fat and *less* MSNF
- **Equipment**: Ice cream making machine
- Overrun: the increase in volume of ice cream over the volume of ice cream mix due to the incorporation of air

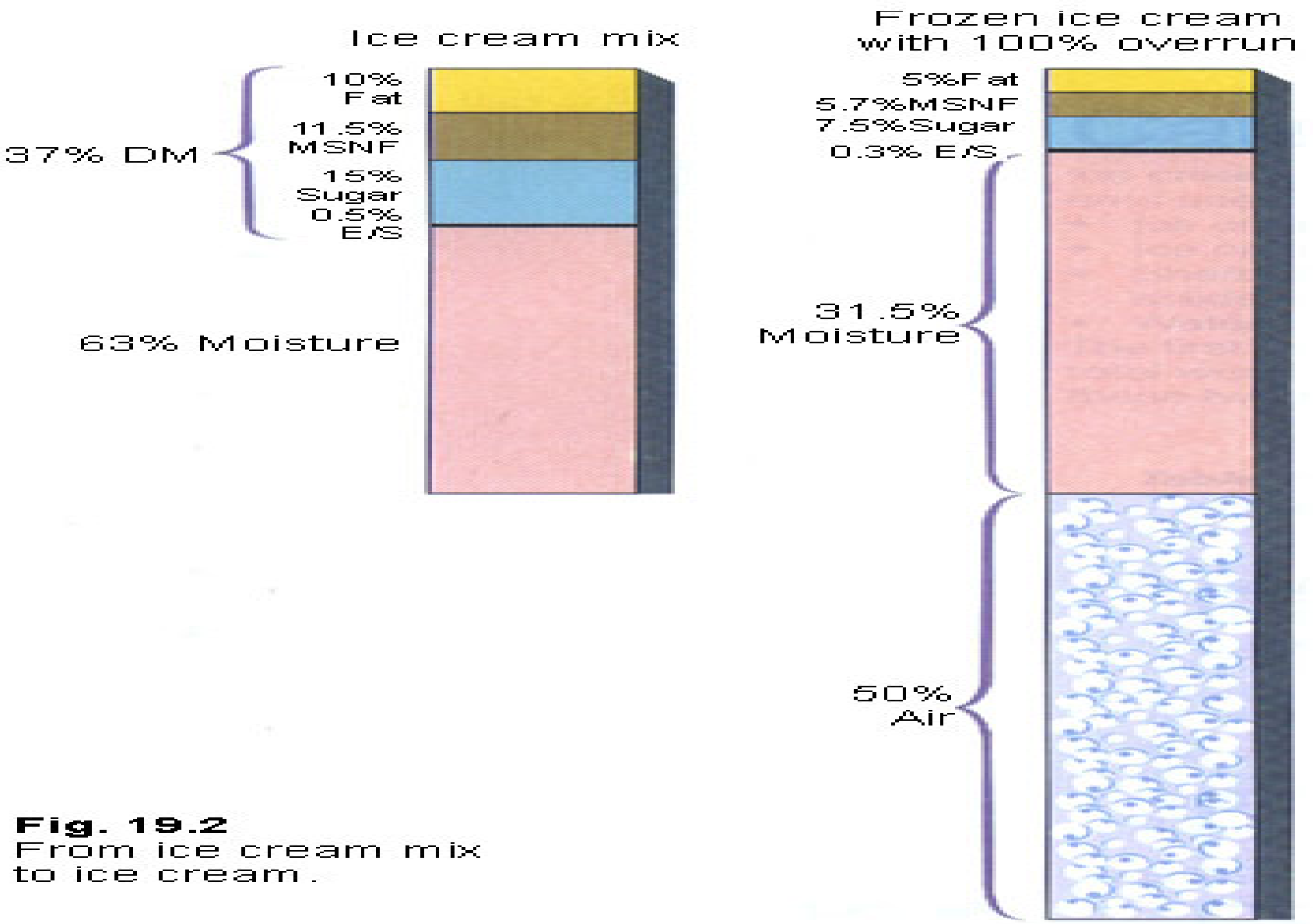
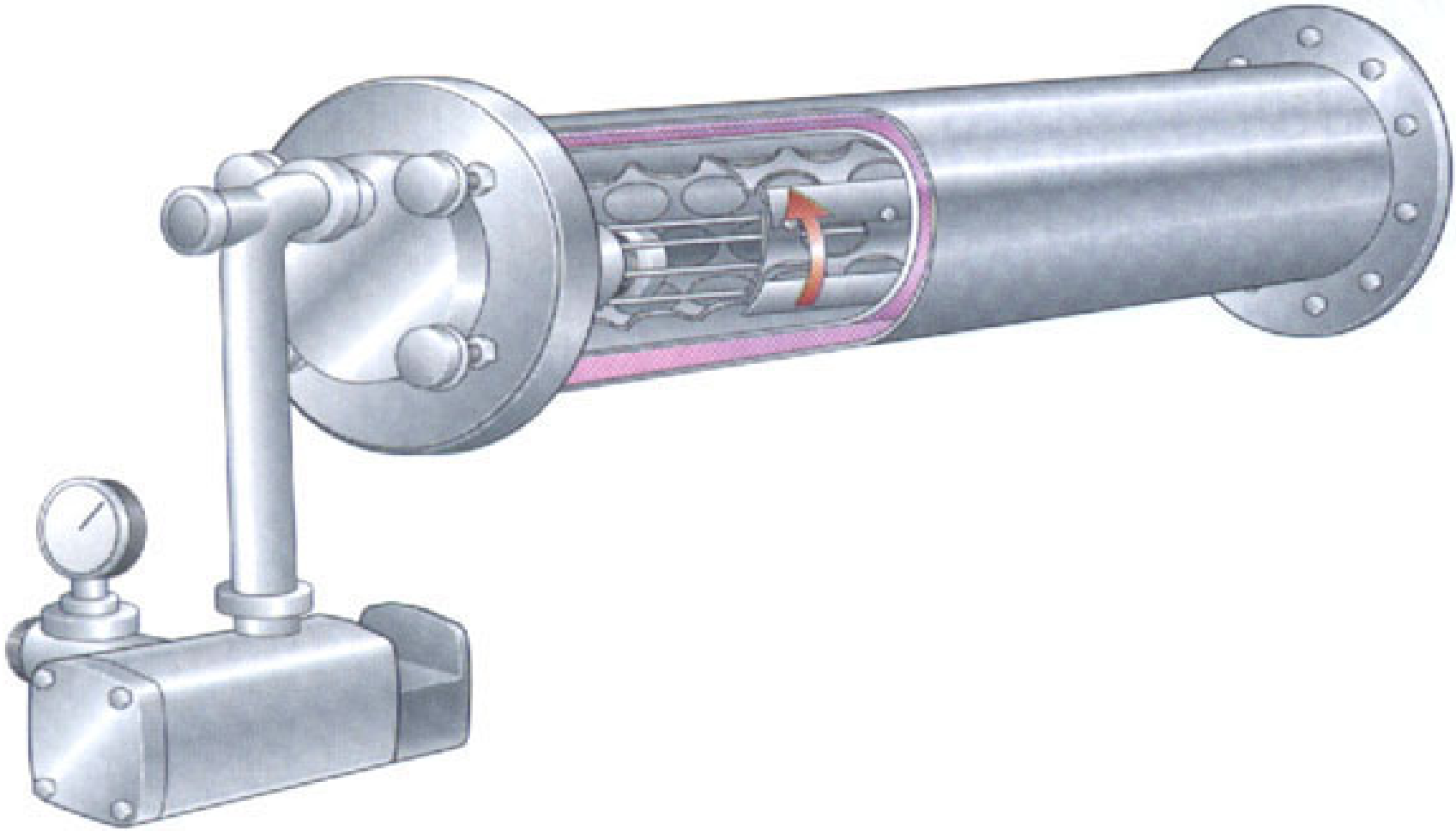


Fig. 19.2
From ice cream mix to ice cream.



Freezing medium

Fig. 19.4 Principle of a continuous ice cream freezer, manually controlled.

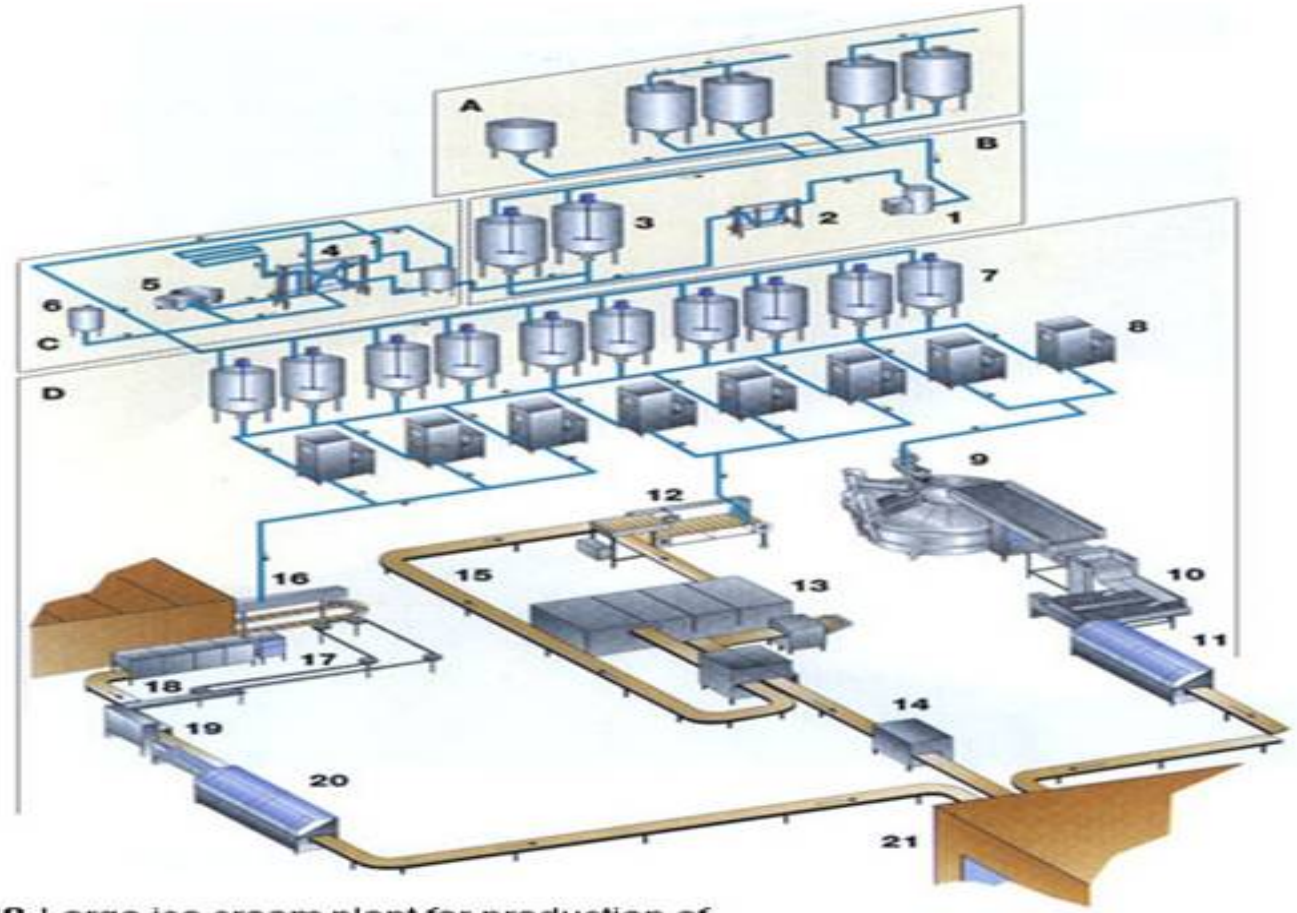


Fig. 19.10 Large ice cream plant for production of 5 000- 10 000 l/h of various types of ice cream.

A Raw material storage

B Dissolving of ingredients and mixing
- 1 Mixing unit
- 2 Plate heat exchanger
- 3 Mixing tanks (at least two for continuous processing)

C Pasteurisation, homogenisation and fat standardisation of the mix
- 4 Plate heat exchanger
- 5 Homogeniser
- 6 Tank for AMF or vegetable fat

D Ice cream production plant
- 7 Ageing tanks
- 8 Continuous freezer
- 9 Bar freezer
- 10 Wrapping and stacking unit
- 11 Cartoning unit
- 12 Cup/cone filler
- 13 Hardening tunnel
- 14 Cartoning line
- 15 Return conveyor for empty trays
- 16 Tray tunnel extruder
- 17 Chocolate enrobing unit
- 18 Cooling tunnel
- 19 Wrapping unit
- 20 Cartoning unit
- 21 Cold storage

Let us make ice-cream for business…








Whey

- Aqueous (serum) protein in milk-contain about half of the TS in the original milk and should be used as animal feed or for human nutrition
- Whey is the by-product of cheese making
- A tremendous quantity of cheese is manufactured and currently, more satisfactory ways of using whey are being explored
- Whey isn’t precipitated at a pH of 4.6 or by rennin, as is casein
- Whey precipitation is seen when the lacto-albumin coagulum sticks to the bottom of the pan and scorches

Composition of fresh whey

- Water: 94%
- Dry matter:6%
- Lactose:4.5%
- Total protein: 0.8-1.0%
- Minerals: 0.5-0.7%
- Citric acid: 0.1%
- pH : 6.4-6.2

Whey utilization

- Direct utilization (non processed whey)
- Manufacture of whey concentrate and powder
- Manufacture of individual ingredients
- Fermentation of whey

Utilization of Whey

- **Utilization of unmodified whey** as cattle feeding; drinking whey
- **Whey can be used as whey concentrate and whey powder**: concentrated by ultra-filtration or nano filtration to yield whey protein concentrates -frequently added to yogurt
- Whey protein isolates are used in infant formulas and bread making to increase the nutritive value
- It is also useful for production of fermented drink, manufacture of alcohol, lactose and producing whey cheese by evaporation the moisture
- Pharmaceutical industry utilizes the lactose
- **Manufacture of individual ingredients (fractions**): protein extraction, lactose manufacture, manufacture of lactic acid from whey

Cont'ed

- Lactose in whey can also be used in yeast fermentation
- Lactose serves as a nutrient for the used microorganisms
- Apart from the production of metabolic products, all nutrients are extracted from whey, which permits easy discharge without any ecological disadvantage
- The metabolic activity of the participating microorganisms results in production of $C0_2$, ethanol and single-cell protein as biomass

Cont'd

- After fermentation of the lactose the BOD in the residual level has been reduced to such a level that the liquid can be discharged directly into the municipal wastewater system without any further processing
- An efficient fermentation process involves the use of a combined culture of bacteria and yeast (Lactobacilli, baker's yeast), permitting a two-stage fermentation
- The entire fermentation process goes over 10-60 h.

Turn Whey into Profitable Business…

- Market for Whey Ingredients …In Ethiopia
- Whey can be processed into ingredients with functionalities for various applications
- Simple concentration followed by drying is still the most common way of processing whey into value-added products.
- The most valuable constituent of whey is the **easily digestible whey protein**. Whey Protein Concentrate (WPC) can be manufactured with different protein content
- The high **lactose** content in permeate may be processed into different grades of lactose for use in the **food** and **pharmaceutical industries**

Long-life milk products

Processing Technolgy

Evaporated and concentrated milks

- **Evaporation and condensation, coupled with packaging in cans, extends the shelf life of milk.**
- **Evaporated milk**: Concentrated to remove 60% of the water of ordinary fluid milk, canned.
- Evaporated milk is concentrated through the process of evaporation 50-55^{0}C in a vacuum chamber.
- Either whole or nonfat milk with 60% of the water removed is then homogenized, fortified with vitamin A and D, canned, and **sterilized in the can 115-118^{0}C** in a pressure canner.
- **Maillard reaction** between the milk protein and the milk sugar: Light tan color -Product

Sweetened condensed milk

- Sweetened condensed milk is concentrated whole or nonfat milk with~ 60% of the water removed, and sugar levels of 40-45% in the finished product.
- Sweetened condensed milk is pasteurized, but not *sterilized*
- Because the high sugar content plays a role in preventing bacterial growth due to the osmotic effect of sugar

Milk powder (Dried milk)

- Dried milk powder may be processed from either pasteurized whole or, more commonly, from nonfat milk
- It is 1st condensed by removing 2/3 of the water and is typically sprayed in to a heated vacuum chamber (spray drying) to dry to less than 5% moisture levels
- It may be dried by spraying a jet of hot air into concentrated nonfat milk
- Most nonfat dry milk is fortified with vitamins A and D

Need to reminisce!!!

- ☑ Evaporated and concentrated milks
- ☑ Sweetened condensed milk
- ☑ Milk powder
- ➢ All products can be produced only where there is :
  - Excess amount milk,
  - Market availability
  - Change of food habit