

# UNIVERSITY OF AGRICULTURE, ABEOKUTA

DEPARTMENT OF ANIMAL PRODUCTION & HEALTH

ANIMAL PRODUCTS AND BY-PRODUCTS (APH505)

MILK & MILK PRODUCTS – **Sogunle**, O.M., Ph.D.

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# Milk

- Defn.: It is a white liquid produced by mammals and it is drunk by people
- **Facts about Milk**
- It is the source of nutrients and immunological protection for the young animals such as calf and kid.
- Shortly before parturition, milk is secreted into the udder in preparation for the new born.
- At parturition, a yellowish coloured, salty liquid 'Colostrum' is secreted. This has very high serum protein content and it provides antibodies to help protect the new born until its own immune system is established.
- The composition of colostrum changes to that of fresh milk within 72hours allowing it to be used in food supply.

# **The Cow's Milk-The essence of Milk Processing**

- ✓ In the cow, the period of lactation or milk production continues for an average of 305 days, producing 7000kg of milk.
- ✓ It should be noted that a calf requires about 1000kg for growth. Hence, the need to process the excess.
- ✓ Within the lactation, the highest yield is 2-3 months post-parturition, yielding 40-50 litres/day.
- ✓ Within the milking lifetime; a cow reaches a peak in production about her third lactation, but can be kept in production for 5-6 lactations if the yield is still good.

## **The Cow's Milk-The essence of Milk Processing (contd.)**

- ✓ About 1-2 months after calving, the cow begins to come into heat again.
- ✓ The cow is usually inseminated about 3 months after calving so as to come into a yearly calving cycle.
- ✓ Heifers are normally first inseminated at 15 months so that she is 2 years when the first calf is born.
- ✓ About 60 days before the next calving, the cow is dried off (there is no milking during this stage). Reasons for this are:
  - **Milk has tapered off because of internal needs of the foetus.**
  - **Udder needs time to prepare for the next milking cycle.**

**The cycle (often repeated for 5-6 lactations) can be summarized as shown below:**

**Age**

**Event**

**0**

**Calf is born**

**15 months**

**Heifer is inseminated for first calf**

**24 months**

**First calf is born – starts milking**

**27 months**

**Inseminated for second calf**

**34 months**

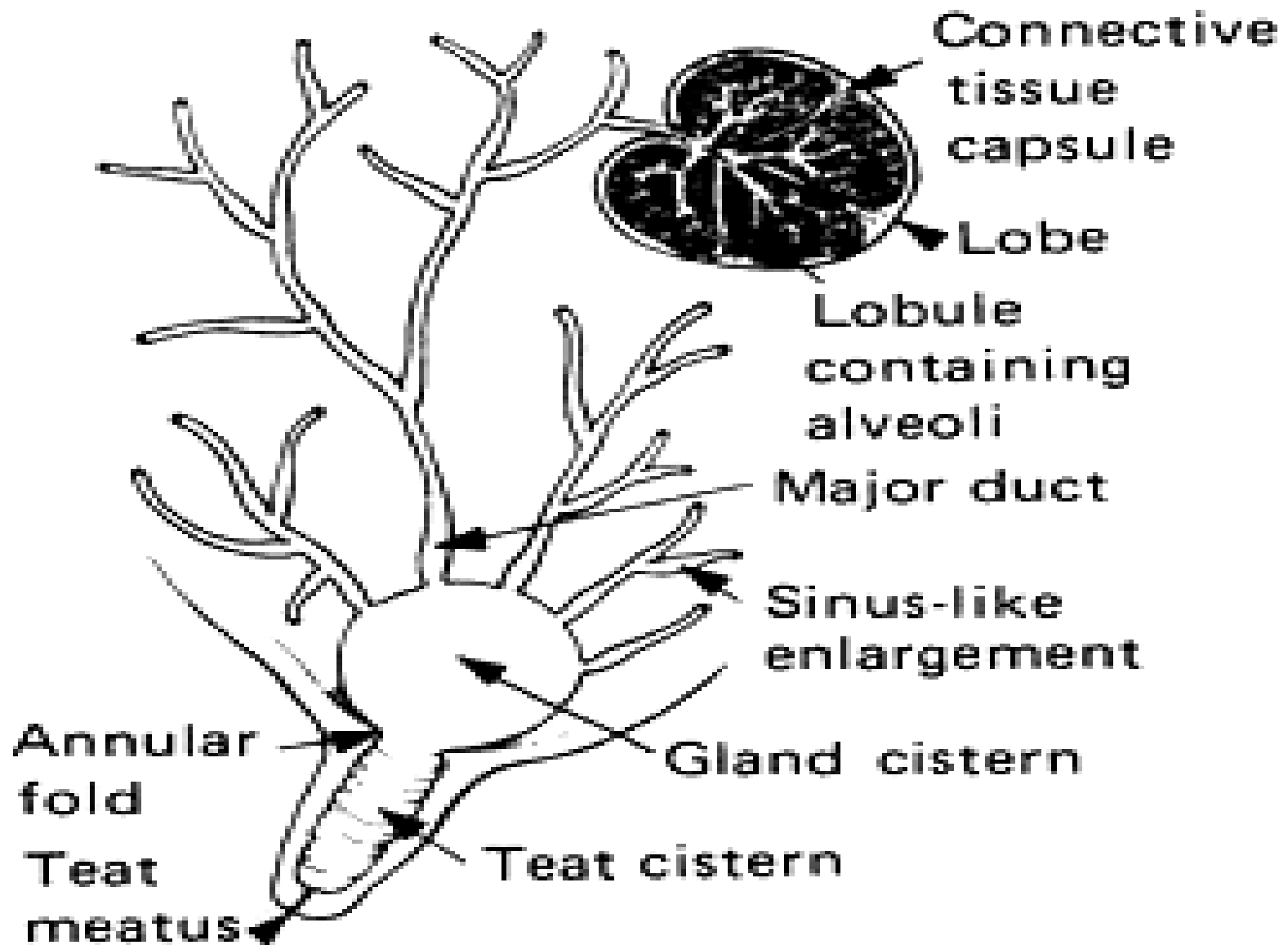
**Dried off**

**36 months**

**Second calf is born –starts milking**

# Milk Biosynthesis/Composition

- ✓ Milk is synthesized in the mammary gland. Within the mammary gland is the milk producing unit, 'the alveolus.'
- ✓ It contains a single layer of epithelial secretory cells surrounding a central storage area called the 'lumen', which is connected to a duct system.
- ✓ The secretory cells are, in turn, surrounded by a layer of myoepithelial cells and blood capillaries.
- ✓ The raw materials for milk production are transported via the blood stream to the secretory cells. It takes 400 to 800 litres of blood to deliver components for 1 litre of milk. The *components* are:
  - ❑ Proteins: The building blocks are amino acids in the blood. Casein micelles begin aggregation in golgi vesicles within the secretory cells.
  - ❑ Lipids: C4-C14 fatty acids are synthesized in the cells.
  - ❑ Lactose: This regulates the volume of milk secreted by controlling the osmotic equilibrium of milk with the blood.



**Udder showing mammary tissues**

# Biosynthesis of Milk

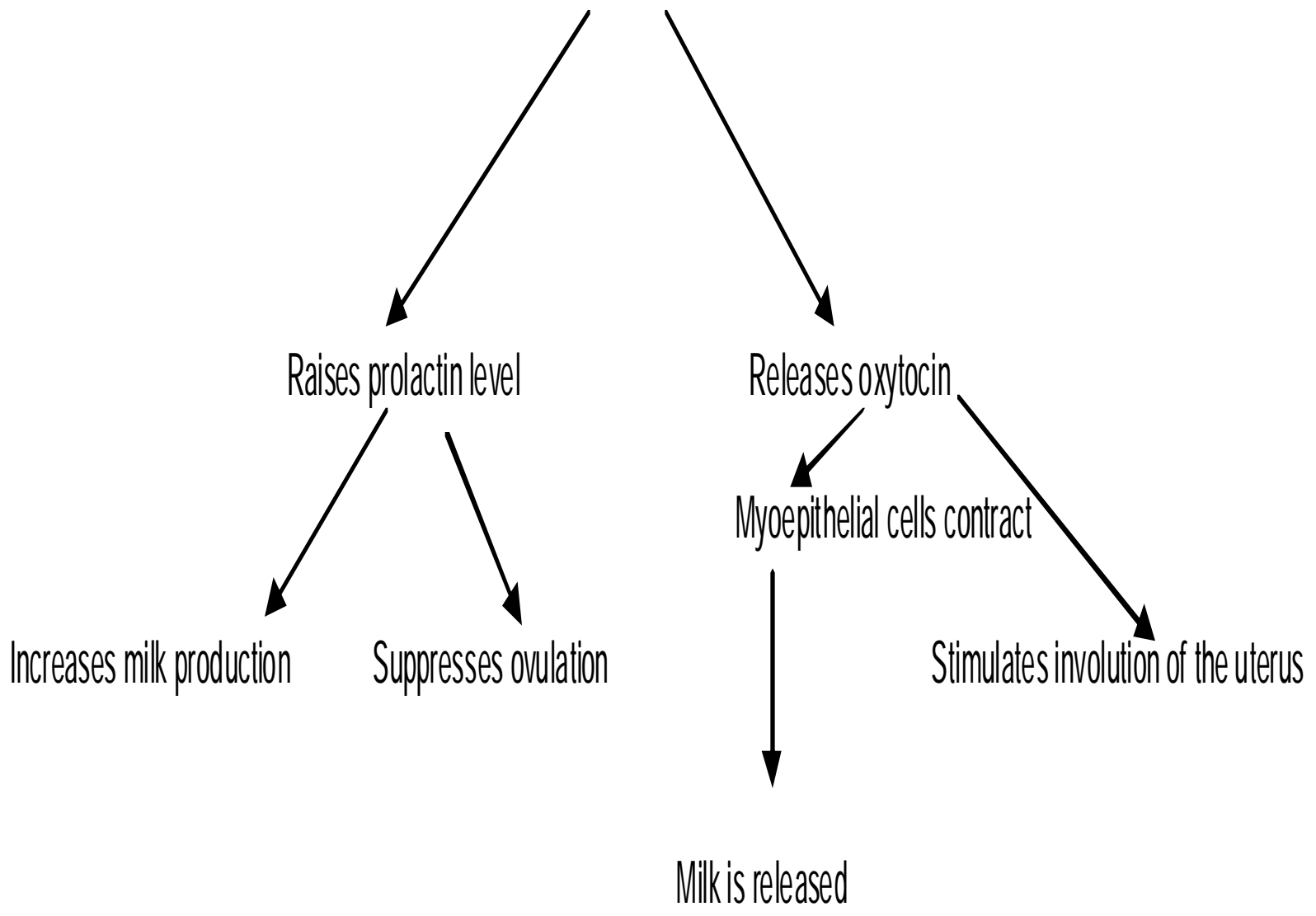
- ✓ The components of milk are synthesized within the cells mainly by the endoplasmic reticulum (ER) attached to ribosomes.
- ✓ The energy for the ER is supplied by the mitochondria.
- ✓ The components are then passed along to the golgi apparatus, which is responsible for their eventual movement out of the cell in the form of vesicles.
- ✓ Both vesicles containing aqueous non-fat components as well as liquid droplets (synthesized by the ER) must pass through the cytoplasm and the apical plasma membrane to be deposited in the lumen.
- ✓ **Milking stimuli** such as a *suckling calf, a warm wash cloth, the regime of milk parlour, vaginal-tactile stimulation, the sight of the milking machine*, etc., causes the release of a hormone called ‘**oxytocin**’ from the pituitary gland below the brain, to begin the process of milk ‘let-down’.



## Biosynthesis of Milk (contd.)

- As a result of oxytocin stimulation, the muscles begin to compress the alveoli, causing a pressure in the udder known as '*letdown reflex*' and the milk components stored in the **lumen** are released into the **duct** system.
- The milk is forced down into the 'teat cistern' from which it is milked.
- The let-down reflex fades as oxytocin is degraded, within 4-7min.
- Below is a flow diagram depicting the influence of milking stimulus

Milking stimulus (suckling of calf)



# Milking & Milking Methods

**Lactation** – the continuous secretion and storage of milk in the udder. The milk ejection or ‘let-down’ reflex effect is short term, inhibited by pain or fear but stimulated by good husbandry practices.

- ✓ At least 10% of secreted milk is retained in the udder as residual milk.
- ✓ Removal of milk is achieved when external forces such as suckling or milking open the teat duct at the teat end.

**Assignment: Write short notes on the two major stages of milk production (minimum of 2 Pages). Submit on Wednesday, 28<sup>th</sup> April, 2010 before 12noon.**

Milk Secretion: is continuous & usually at a constant rate for at least 12 hours resulting in a gradual increase in internal udder pressure. The ejection of milk is a neuro-hormonal reflex initiated by various stimuli at milking time. **Note: the stages of milk production are:**

- 1. Cytologic and enzymatic differentiation**
- 2. Copious secretion of milk components**

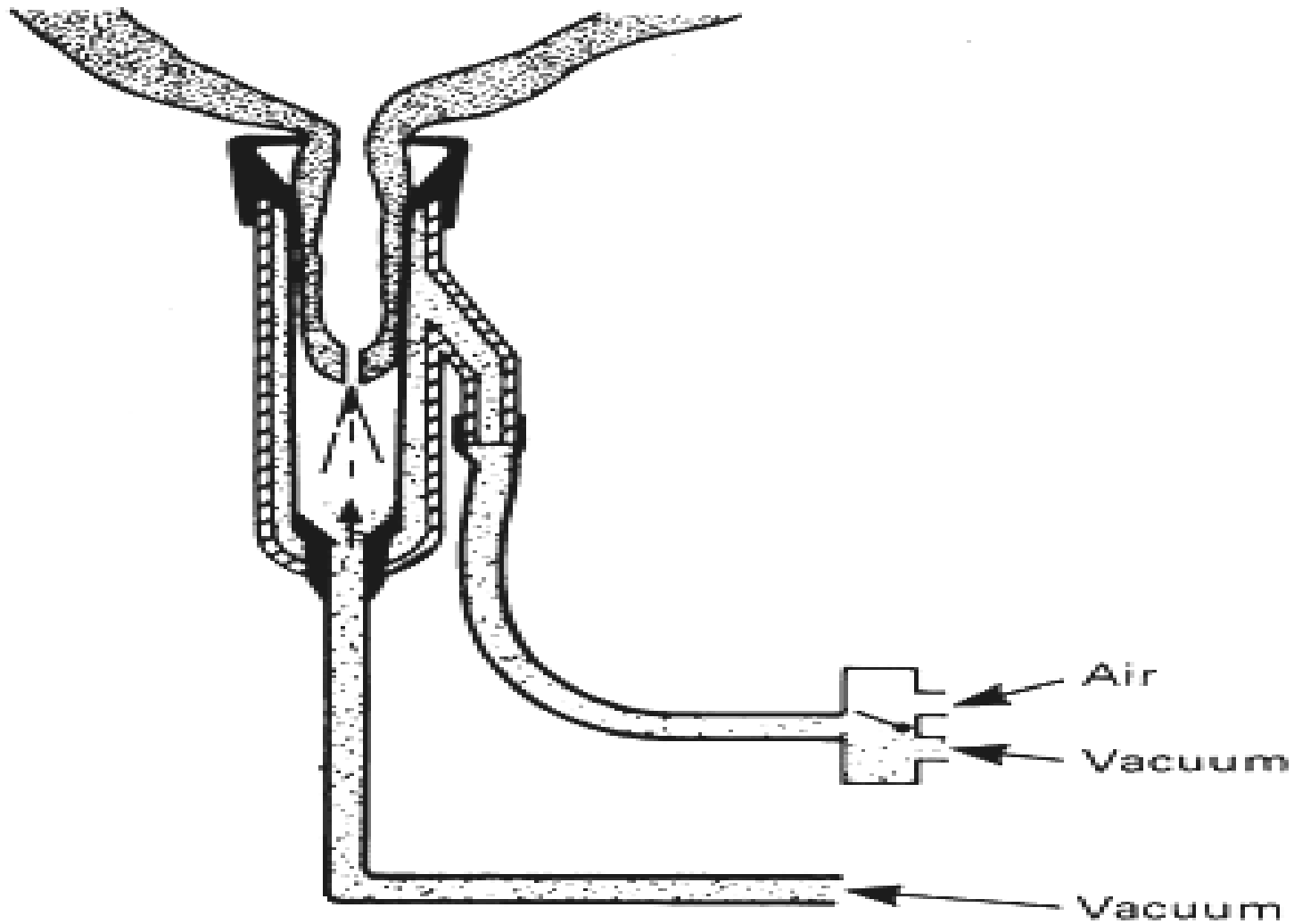
# Milking Methods

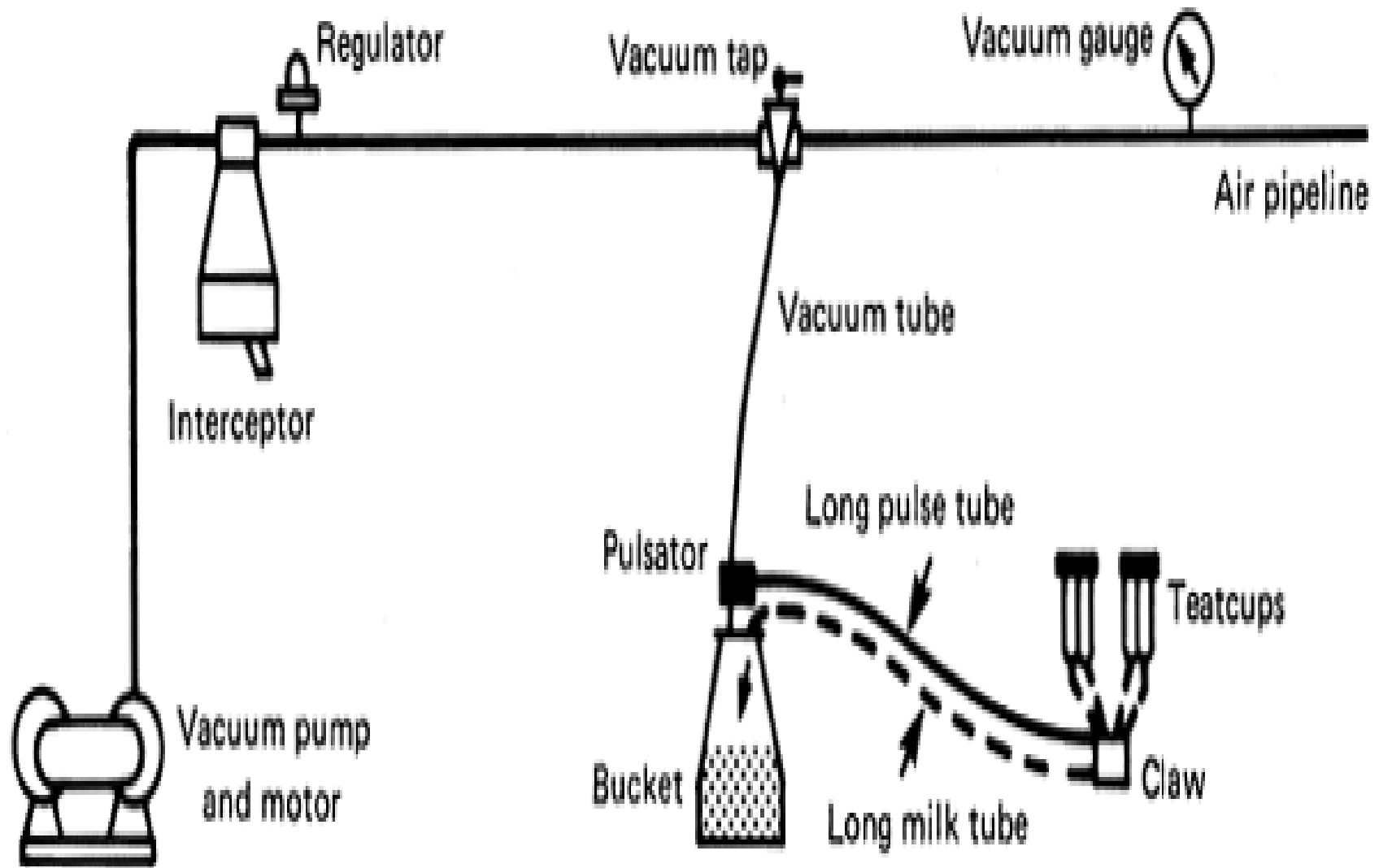
- Hand Milking: Done using clean dry hands preferably with the full hand.

## **NB.**

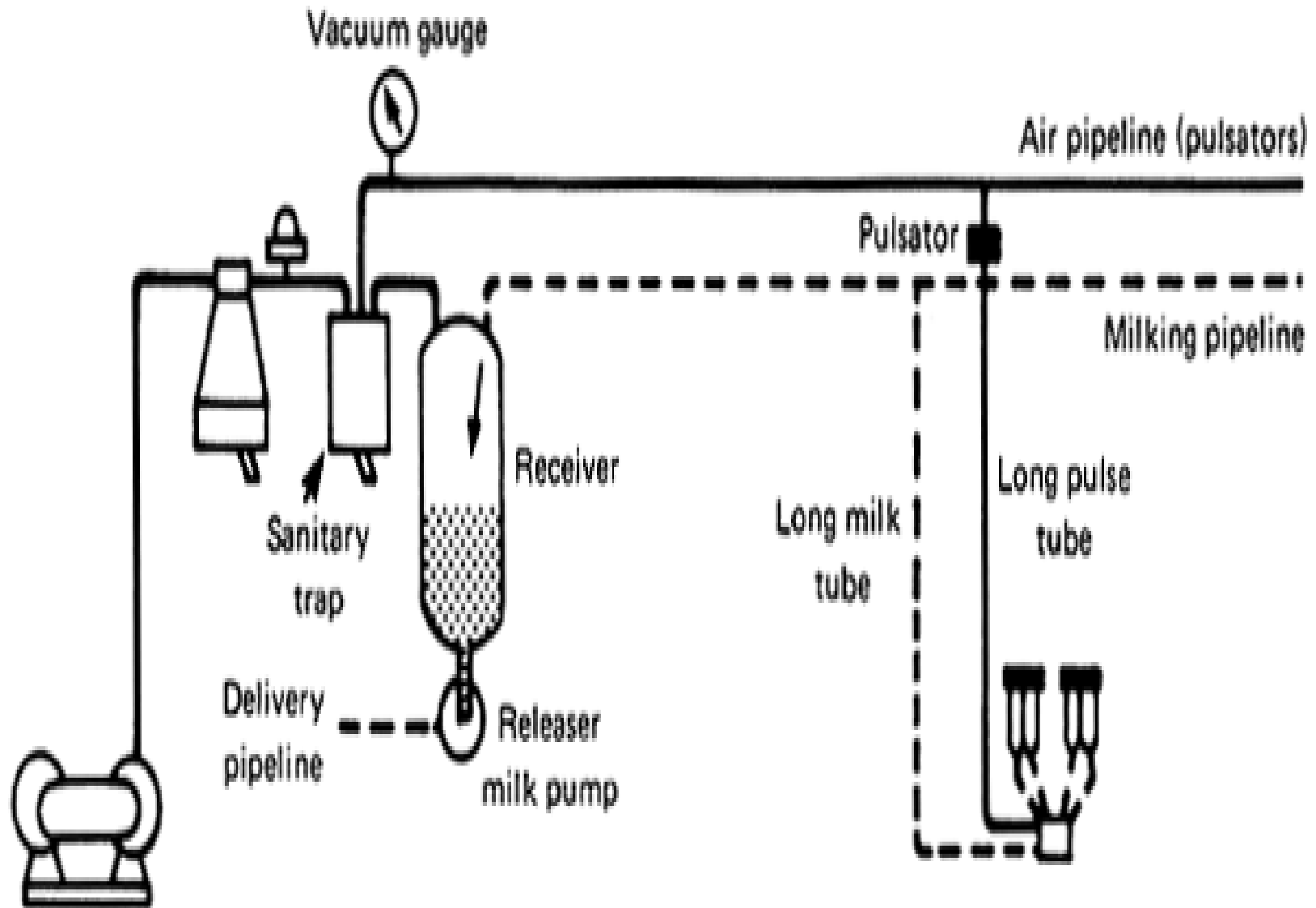
- ✓ **Avoid end-of –milking stripping with the fore finger and thumb**
- ✓ **Rear quarters should be milked first as they contain most milk**
- ✓ **Milking bucket should be hooded to reduce contamination from dust and hairs.**
- Machine Milking: Designed to create a pleasant milking sensation for the cows and to avoid any possible hazard to udder's health.

# A typical milking machine

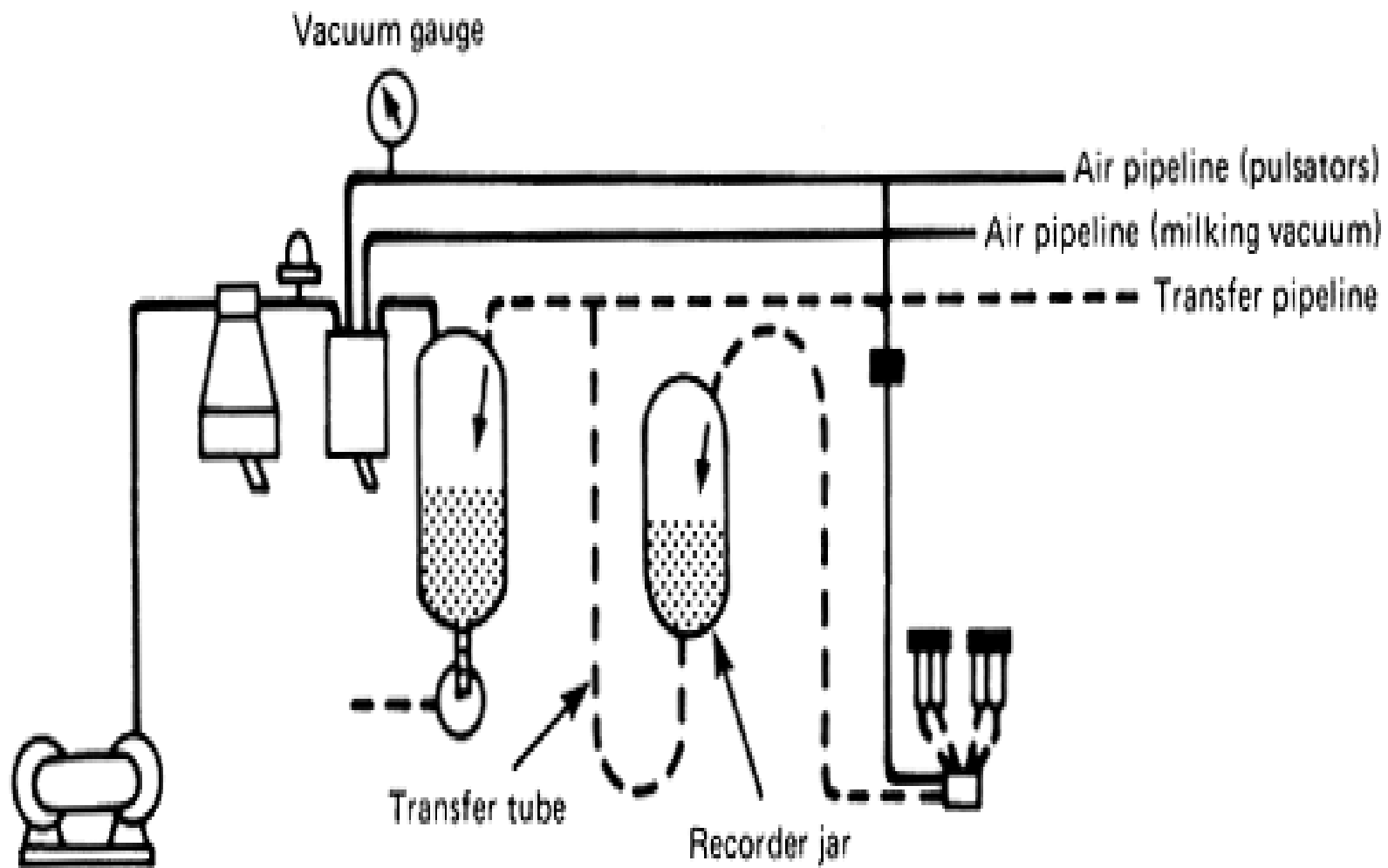




(a) Bucket (cowshed)



**(b) Milking pipeline (cowshed and parlour)**

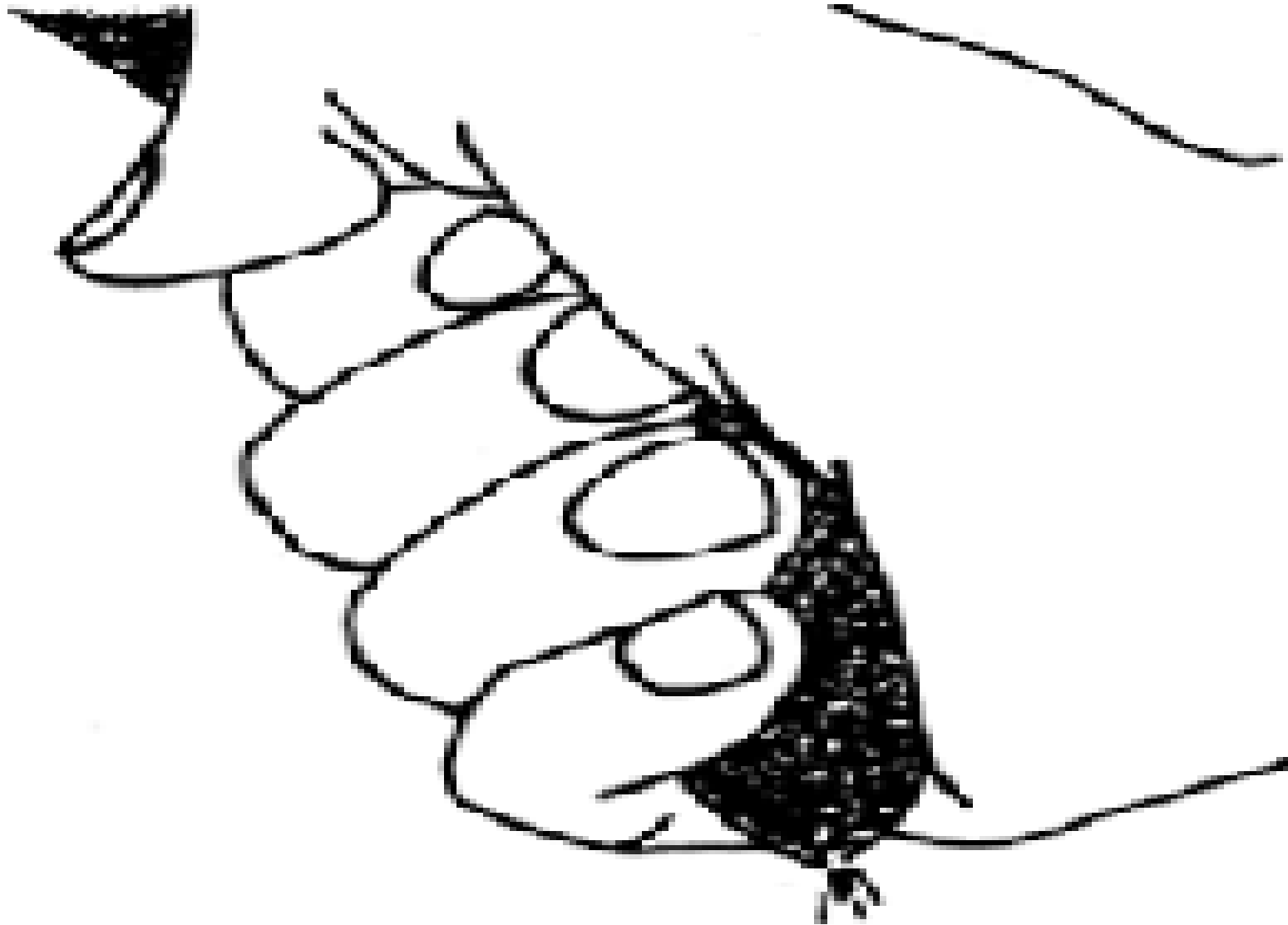


(c) Recorder (parlour)

Principal types of milking machines

Milk - - -  
 Air ———





**Hand milking with the full hand**

## Effect of milk handling on quality and hygiene

- 1) Cleanliness:- The environment of production has a great effect on the quality of milk produced. *Hygienic quality assessment tests include sensory tests, dye reduction test for microbial activity, total bacterial count (standard plate count), tolerable acidity, somatic cell count, antibiotic residues and added water.*

*The two common dye reduction tests are done using Methylene blue and Resazurin. These are synthetic compounds that accept electrons and change colour as a result of reduction.*

- ✓ Methylene blue turns from blue to colourless while resazurin turns from blue to violet to pink and to colourless. The reduction time is inversely correlated to bacterial numbers.
- 2) Temperature: Milk production and distribution in the tropics is more challenging due to the requirements for low temperature for milk stability. It is noteworthy that as the temperature increases, the numbers of bacteria/ml of milk after 24 hours increase. *For instance at 5<sup>o</sup>C the bacteria count/ml is 2 600 and as the temperature rises to 20<sup>o</sup>C, the bacteria count/ml geometrically increases to 450 000. Traditionally, this is overcome by stabilizing milk through refrigeration, immediate consumption of warm milk, by boiling or by conversion into more stable products like fermented milk.*

- Antibiotics: It noteworthy that antibiotics are frequently used to control ‘mastitis’ (inflammation of the lining of the udder). The presence of antibiotic residues in milk is very problematic, for at least three reasons;
  - In the production of fermented milks, antibiotic residues can slow down or destroy the growth of the fermentation bacteria.
  - Some people are allergic to specific antibiotics and their presence in food consumed can have severe consequences.
  - Frequent exposure to low level of antibiotics can cause resistance, through mutation, so that they are ineffective when needed to fight a human infection.

For these reasons, it is extremely important that milk from cows being treated with antibiotics is withheld from milk supply.

# Antimicrobial Systems in Raw Milk

- The natural antimicrobial systems in milk include:
  - ✓ **Lysozyme:** An enzyme that hydrolyses glycosidic bonds in gram positive cell walls. Its effect as a bacterio-static mechanism in milk is probably negligible.
  - ✓ **Lactoferrin:** An iron-binding protein that sequesters iron from micro-organisms thus taking away one of their growth factors. Its effect as a bacteriostatic mechanism in milk is also probably negligible.
  - ✓ **Lactoperoxidase:** An enzyme naturally present in raw milk that catalyzes the conversion of hydrogen peroxide to water. When hydrogen peroxide and thiocyanate are added to raw milk, the thiocyanate is oxidized by enzyme hydrogen peroxide complex thus producing bacteriostatic compounds that inhibit gram negative bacteria such as *E. coli*, *Salmonella spp.* and *Streptococci*

# Milk Products

- Defn: Milk (**dairy**) products are generally defined as food stuffs produced from milk. A production plant for such processing is called a **dairy**.
- There are two broad divisions of milk products, viz., **Fluid milk products** and **Fermented milk products**.
- ✓ Fluid milk products include: Beverage milk, Cream, Recombined milk and Chocolate milk.
- ✓ Fermented milk products include: Cultured buttermilk, Acidophilus milk, Sour cream and Yogurt.

# FLUID MILK PRODUCTS

- **Beverage Milk:** This is either produced by partially skimming the whole milk, or by completely skimming it and then adding an appropriate amount of cream to achieve the desired final fat content. Vitamins A and D are often added in the form of water soluble emulsion to offset that quantity lost in the fat separation process.
- **Cream:** The fat-rich stream in the separation of whole milk. This usually comes off the separator with fat contents in the 35-45% range. Cream is used for further processing in the dairy industry for the production of ice cream and butter. Those used for packaging and sales are pasteurized to ensure freedom from pathogenic bacteria.
- **Recombined milk:** beverage milk can be prepared by recombining skim milk powder and butter with water. The concept is simple:
  - Skim milk powder is dispersed in water and allowed to hydrate.
  - Butter is then emulsified into this mixture by either blending melted butter into the liquid mixture while hot or by dispersing solid butter into the liquid through a high shear blender device.
  - A non-dairy fat source may be used. The recombined milk product is then pasteurized, homogenized and packaged as in regular milk production.
  - The final composition is similar to that of whole milk, approximately 9% milk solid-not-fat and either 2% or 3.4% fat.

## **FLUID MILK PRODUCTS (contd.)**

➤ **Chocolate milk:** An industry standard for the production of chocolate milk consists of:  
93% Milk, 6.3% Sugar, 0.65% Cocoa powder and 0.05% carrageenan (locust bean guar) used as stabilizer.

The sugar, cocoa powder and carrageenan are dry blended and added to cold milk with vigorous agitation and then pasteurized. The final product is usually standardized to either 2% or 1% fat.

# FERMENTED MILK PRODUCTS

- These are products that pass through fermentation aided by the addition of starter culture such as *Streptococcus thermophilus* (lactis) , *Lactobacillus bulgaricus*, etc.
- ✓ **Cultured buttermilk:** this product was originally the fermented by-product of butter but today it is common to produce cultured buttermilk from skim or whole milk. The culture most frequently used is *Streptococcus lactis*. Milk is usually heated to 95°C and cooled to 20-25°C before the addition of the starter culture which is added at 1-2% and the fermentation is allowed to proceed for 16-20 hours to an acidity of 0.9% lactic acid.
- ✓ **Acidophilus milk:** skim or whole milk is fermented with *Lactobacillus acidophilus* (LA) which is said to have therapeutic benefits in the gastrointestinal tract. The milk is heated to high temperature (95°C for 1 hr) to reduce the microbial load and favour the slow growing LA culture. The milk is inoculated at a level of 2-5% and incubated at 37°C until coagulated.



# FERMENTED MILK PRODUCTS (contd.)

- ✓ **Sour cream:** the cream after standardization is heated to 75-80°C and is homogenized at >13MPa to improve the texture. The starter is similar to that used for cultured buttermilk but its fermentation is stopped at an acidity of 0.6%
- ✓ **Yogurt:** Whole milk, partially skimmed milk, skim milk or cream may be used in the production of yogurt. In the use of whole raw milk, the following conditions must be met: **Low bacteria count, Free from antibiotics and No contamination by bacteriophages.**

The ingredients used are:

- i. Other dairy products such as concentrated skim milk, non-fat dry milk, whey and lactose
- ii. Sweeteners: glucose or sucrose
- iii. Stabilizers: gelatin, carboxymethyl cellulose, locust bean guar
- iv. Flavour: contributed mainly by the following fermentation products: Lactic acid, Acetaldehyde, Acetic acid and Diacetyl
- v. Fruit preparations: including natural and artificial flavouring colour.

The starter culture for most yogurt production is a symbiotic blend of *Streptococcus salivarius* subsp *thermophilus* (ST) and *Lactobacillus delbrueckii* subsp. *Bulgaricus* (LB). When used together, the rate of acid production is higher.

## Yogurt (contd.)

- **Symbiosis of the starter culture:** ST grows faster and produces both acid and CO<sub>2</sub>. The formate (an acid) and CO<sub>2</sub> produced stimulate LB growth. On the other hand, the proteolytic activity of LB produces stimulatory peptides and amino acids for use by ST. The yogurt mixture coagulates during fermentation due to drop in pH.
- Types of yogurt:
  1. Stirred style yogurt (mainly industrial)
  2. Set style yogurt: In this type, the yogurt is packaged immediately after inoculation with the starter culture and is incubated in the packages.

Others are:

- Fruit-on-the-bottom style: fruit is layered at the bottom followed by inoculated yogurt. Incubation occurs in the sealed cups.
- Stirred style yogurt with fruit preparation.

**Assignment:** Describe in detail the manufacturing of a stirred style yogurt.

# An overview of milk products



# Cheese production

- Defn.: this is produced by coagulating milk, separating it from whey and letting it ripen generally with bacteria and sometimes also with molds.
- To make firmer, longer lasting cheese and speed the separation process, an enzyme called 'rennet' is added. *Rennet is found in the stomach of milk-drinking mammals. It enables the young to digest the mother's milk. **It is extracted from the lining of the stomach of a milk-fed calf and made into powdery form.***
- ***Below is a flow chart on cheese making process:***



# Glossaries

- ❖ Milk: gotten after optional homogenization, pasteurization in several grades after standardization of the fat level.
- ❖ Cream: the fat skimmed off the top of milk or separated by machine-centrifuges.
- ❖ Sour cream: cream that has been fermented by the bacteria *Streptococcus lactis* and *Leuconostoc citrovorum*.
- ❖ Condensed milk: milk which has been concentrated by evaporation often with sugar added for longer life in an open can.
- ❖ Curds: the soft curdled part of milk.
- ❖ Whey: the liquid drained from curds and used for further processing.
- ❖ Butter: mostly milk fat, produced by churning cream
- ❖ Buttermilk: the liquid left over after producing butter from cream.
- ❖ Caseinate: a casein (milk protein) salt formed by compounding casein with a metal such as calcium or sodium.