Chapter one : Biological and Physical Properties of Milk and Milk Components

Milk Hygiene: The term milk hygiene covering both:

1- **The bacteriological quality of milk.**

2- **The herd health aspects that can affect both:**

a-The quality of milk.

b-The yield of milk.

The FDA definitions of milk:

1- Milk is defined from the legal point of view as the whole lacteal secretion obtained by the complete milking of one or more healthy cows and should be obtained 15 days before calving or 5 days after calving (i.e. free from Colostrum).Milk should contain not less than 8.25% milk solids not fat (MSNF) and not less than 3.25% milk fat.

2- Milk is defined from the biological point of view as the normal secretion of the mammary glands of Mammals which is designed as a food for the young.

3- Milk is defined from the chemical point of view as a complex chemical nature. It is an emulsion of fat in a watery solution of sugar and mineral salts and with protein in a colloidal dispersion (finely divided particles 1-100 millimicron in diameter which is between the smaller size particles in ution (< 1 millimicron) and the larger size particles in a suspension (250 millimicron). The term" milk" always will be understood as referring to the milk of the cow unless other species are mentioned specifically e.g. Goat's milk, Camel's milk and Buffaloe's milk. The milk of different species although containing the same constituents in general but varies in composition and properties in minor ways.

Colostrum:

It is defined as the milk that produced by an animal immediately after parturition and for the three to ten milkings (5 days).

The composition of the colostrum differs from the normal milk in that :

a- It is lower in water %, lactose % and fat % than normal milk.

b- It is higher in casein %, albumin %, Globulin % and Ash% than the normal milk.

c- There is approximately ten times more Vit .A in colostrum than in normal milk (Vitamin A is of value because it aids in the control of infectious diseases).

d-Colostrum also differs considerably from normal milk in appearance and general properties.

1- It has a reddish - Yellow color.

2- It has an abnormal odour.

3- It has a bitter taste.

4- It is a very slimy and viscous in consistency.

5- It has a salty taste.

6- It has acidic reaction (Titrable Acidity (TA)% =0.45 %).

7- Because of its high total solids contents, colostrum also has a much higher specific gravity (1.079) than the normal milk (1.032).

8- It is readily coagulated by heat due to its high contents of Globulin and Albumin and its acidic reaction.

The most striking difference between the normal milk and the colostrum is the Globulin contents which often reaches 12-13% in the colostrum .This kind of Globulin is called Immunoglobulin because it contains antibodies which serve to protect the new-born calf against the invasion of bacteria. When the colostrum examined under the microscope, it shows a large numbers of leucocytes. The lower percent of lactose in the colostrum protects the new-born calf from diarrhea. The antibodies can be absorbed by the intestinal tract during the first 24 hours of the calf's life which gives the new-born calf passive immunity from its dam.

Table 1 : the average composition of colostrum and normal milk (13 weeks after parturition)

components	colostrum	Normal milk
Casein	4.83%	2.5%
Globulin + Albumin	15.85%	0.8%
Lactose	2.5%	5%
Fat	3.4%	4%
Ash (minerals)	1.8%	0.7%
Total solids	28.31%	13%

Raw milk:

Milk which is delivered in its natural state after it leaves the cow and without any heat treatment other than cooling.

Kinds of raw milk:

A- Certified raw milk:

Fresh, clean, safe and pure wholesome milk which is drawn from healthy cows, by healthy people and under the very best sanitary conditions and delivered promptly to the consumer without contamination or alteration due to chemical or microbial agencies and consumed without heat treatment.

Certified raw milk should be produced and prepared with the following designations:

1-Efforts should be applied by Veterinarians for periodical clinical examination of dairy animals to control animal diseases especially those of zoonotic importance like Tuberculosis, Brucellosis, mastitis and other diseases.

2- Obtained by complete milking of healthy cows excluding that obtained within 45 days before and 7 days after calving.

3- The standard fat percent is 3.5-4% whereas that for solids -not-fat is 8-8.5%.

4- It should be cooled to less than 10 °C immediately after it is drawn from the udder and consumed within a period not more than 30 hours after milking.

5-The total aerobic bacterial count should be < 10000 cfu/ml.

6- It should be free from Coliform i.e Coliform plate count is 0 cfu/ml.

7- The methylene blue reduction test (MBRT) should be 8 hours.

B-Grade A raw milk:

It is obtained by complete milking of healthy cows under good sanitary conditions and has slightly higher bacterial count than the certified milk and consumed after heat treatment.

It should be produced and prepared with the following designations:

1-It should be produced under very best sanitary conditions.

2- The percentage of lactic acid (TA%) should be 0.20%.

3-The amount of sediment should be not more than conditions, 0.015-0.075mg/ 500 ml milk.

4- The total aerobic bacterial count should be 200000 cfu/ml.

5- The total coliform count should be ≤ 10 cfu/ml.

6- It should be free from any foreign flavor.

7- Methylene blue reduction test (MBRT) should be 25.5 hours.

C-Grade B raw milk:

It should be obtained by complete milking of healthy cows under good hygienic conditions and has higher bacterial counts than grade A raw milk and consumed after heat treatment. It should be used for manufacturing processes.

It should be produced and prepared with the following designations:

1- It should be produced under good sanitary conditions.

2- The percentage of lactic acid (TA%) should be ≤0.20%.

3- The amount of sediment should be not more than 0.075 mg/500 ml milk.

4- The total aerobic bacterial count should be 500000 cfu /ml.

5- The total coliform count should be <100 cfu/ml.

6- It should contain foreign flavor.

7- The methylene blue reduction test (MBRT) should be 2.5-5 hours.

Pasteurized milk:

It is the milk that has been subjected time-temperatures combination sufficient to destroy all spoilage and disease-producing types of bacteria that may be present in the raw milk and should be stored under refrigeration. It has total aerobic bacterial counts 20000 cfu/ml.

Homogenized Pasteurized milk:

It is pasteurized milk that has been subjected to the homogenization process, i.e the fat globules are broken apart and remain dispersed in a stable emulsion in the milk serum and no cream layer is formed on milk after homogenization.

Sterilized milk:

It is the milk that has been subjected to one of the commercial sterilization process to destroy all kinds of bacteria that may be present in the raw milk. It has a longer shelf-life without refrigeration.

Skim milk:

It contains all the solids of milk excepting the milk fat. The percentage of its fat is 0.5%.

Evaporated milk:

Condensed whole milk or skim milk are referred to products with increased solids content and achieved by the partial removal of water at atmospheric pressure.

Milk powder

Dried milk products are made by removing moisture from milk to produce high-solids food which is preserved from microbial spoilage by their low water activity. The percentage of moisture should be < 5%.

Adulterated milk:

One of the most lucrative ways of making money is to adulterate milk and this can be achieved by various means eg :

Methods of adulterating milk:

1- Skimming.

2- Watering.

3- A combination both skimming and watering.

4- The addition of preservatives to improve the keeping quality of milk (i.e. to increase the shelf-life of milk) or even to delay the spoilage for a considerable period of time e.g. addition of H_2O2, Antibiotics, formalin etc. and this process is forbidden legally.

5- Substitution of vegetable fat for milk fat.

6- Addition of coloring agents to improve the appearance of the cream layer.

7- The addition of sodium carbonate or soda to neutralize the acidity of milk

8- Accidental adulteration. e.g. use of chemicals in the control of insects, pests, in the control of mastitis and in the cleaning and sanitation of milking utensils also antibiotics in the treatment of mastitis.

Physical Properties of Milk The colour of milk:

The colour of the milk ranges from a bluish-white to a golden yellow or yellowish white. The milk in large quantities appears entirely opaque while in thin layers it is somewhat transparent. The white colour of the milk is due to the reflection of light by the dispersed fat globules, calcium caseinate and calcium phosphate. The yellow colour of the milk is due to the carotene pigment that is found in the green plants. The carotene pigment is a fat soluble yellow pigment and it is considered as a precursor of Vit. A. When the green grass eaten by the animal, a portion of the carotene fined its way into the blood stream. The depth of the yellow colour depends upon the amount of pigment present in the blood when the milk is secreted. Both riboflavin and lactoflavin (lactochrome pigment) are responsible for the bluish color of milk. Such pigment is water soluble (occurs in solution in milk) but it is visible only in the whey. Milk from which the fat has been removed shows a bluish tint. In normal milk the riboflavin is masked by the milk constituents.

Factors affecting the colour of milk:

1-Breed of animal: the proportion of the carotene retained in the body varies with the individual of animal for e.g. the Guernsey and Jersey

breeds produce fat with deepest yellow colour while the Holsteins and Ayrshires produce fat with the lightest colour.

2- Feeds: some feeds are rich in carotene while others are not. Green forage and carrots tend to produce milk with deeper yellow colour than that produced by hay, white corne and oats. Feed is responsible for seasonal variation in the colour of the butter. In the spring and summer seasons the butter has a deep golden yellow colour because the cows have the access to green grass while in winter the butter is almost white in colour I because the cows have access to dry feed.

3- Species of animal: Buffaloes have bluish white milk while cows have golden yellow milk.

The significants of knowing the colour of the milk:

1- To detect any abnormal colour of milk as in mastitis.

2- Certain bacteria produce pigments in milk e.g. *Pseudomonas synxantha* **produce yellow pigment.** *Bacterium erythrogene* **produce red pigment.**

3-The detect skimming of the milk.

Flavor of milk:

The term flavor means a combination of both taste and odor of milk.

Odour: Freshly drawn milk has a characteristic although not pronounced odor. The odor of milk disappears when the milk is allowed to stand a few hours or following cooling or following aeration, where this practice is followed immediately after milking. The odor is volatile and disappears when the milk is exposed to the air. Smelling of the milk is important detection of any abnormal odor or any spoilage.

Taste: Freshly drawn milk tastes slightly sweet to most people and the pleasing taste of milk may be correlated with a high lactose and relatively low chloride content. A low lactose and high chloride content probably would mean milk with salty taste. At the end of the lactation period the milk produced by a cow often has such a salty taste, also mastitic milk has a salty taste.

Source of abnormal tastes and odours:

1-Feeding: From the feed of cow the odors are taken up by the blood and secreted in the milk e.g. wild Onions, Garlic, Cabbage, Turnips, various weeds in the pastures and feeding of silage before milking. The

most common off flavor in raw milk is caused by feed. Any feed with strong smell can cause off flavours in the milk. Silage, weeds, grasses, and moldy feeds all cause off flavours. Remove cows from pasture 2 to 4 hours before milking. Feed silage in the barn only after milking instead of before. Be sure there is plenty of ventilation in the barn.

2-The environment: From the environment of the cow absorption of pronounced odors to which milk is exposed i.e. exposed to air of a barn containing undesirable odor.

3-Microbial: (from the growth of microorganisms). Decomposition of the milk constituents resulting from the growth of bacteria and other microorganisms.

4- Foreign material present in the milk for example:

a- Fly spray used in keeping flies off the cow during summer months may reach milk.

b- Iron and cupper containers.

c- Drugs e.g antibiotics.

d- Sanitizers e.g chlorine.

5-Changes due to chemical action e.g. oxidizing flavor of milk.

6-From the cow herself: Due to disturbed physical condition in this case the substances that giving the objectionable taste are s with the milk. Due to diseases such as mastitis or due to metabolic disorder such as ketosis (large amount of ketones present in the milk) or due to physiological conditions such as the Colostrum and milk at the end of lactation period.

Significants of flavor evaluation:

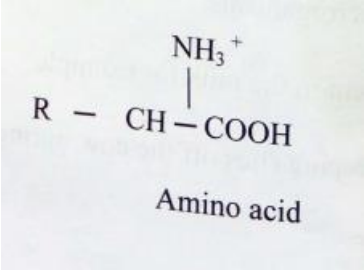
To detect any abnormal taste such as Acidity, Bitterness, Rancidity, Saltiness and oxidized flavour.

Note: Flavor producing feeds should be fed within two to four hours prior to milking so that the flavor will not appear in the milk. Sensory evaluation of milk flavor is called (organoleptic test).

Chemical reaction of milk:

Fresh milk shows an amphoteric reaction, that is, it turns red litmus to blue and blue litmus to red. Amphoteric reaction is partly due to the

proteins, whose amino acids having in their chemical structure both amino groups (basic) and carboxyl group (acidic) react with both bases and acids. The phosphates, some of which are acidic and some basic also enter into these reactions.



PH:

Is expressed as the concentration of hydrogen irons i.e it is a measure of ionized acids present in milk and it reveals the intensity of acidity. Fresh milk has pH of approximately 6.4-6.8 with an average of 6.6 which indicates that the milk is slightly acid (on the acid side of neutrality). The pH can be measured by using pH meter or pH paper. When the normal fresh milk is titrated with an alkali solution using phenolphthalein as an indicator, it appears acid and the acidity will be found to vary from 0.10% to 0.26% calculated as lactic acid.

Apparent or Natural acidity:

All normal constituents of milk which endow it with certain acidity are listed in the following table.

Table 2 : the acidity contributed by milk constituents.

The constituents	The approximate TA% contributed by each constituent
Carbon dioxide	0.01-0.02%
Citrate	0.01%
Casein	0.05-0.08%
Albumin	0.01%
Phosphates	0.05-0.07%

Developed acidity: It is lactic acid contents due to lactic acid fermentation. The organism causing the reaction is Streptococcus lactis

Real acidity or Titratable acidity TA%:

It is a measure of both developed and natural acidity present in milk. It is a measure of both ionized and unionized forms of acids present in milk i.e. it means the amount of lactic acid present in 100 ml of milk. TA% ranges from 0.12 0.16% with an average of 0.14%. It reveals the total weight of acid present in milk. It can be measured by titrating fresh milk with an alkali solution (0.IN NaOH) using phenolphthalein as an indicator. phenolphthalein is colorless in acid and pink in alkalin medium.

Acidity Degree (AD): It is the amount of 0.1 N NaOH required to the acidity in 100 ml of milk. AD= R X10 R=ml of 0.1 N NaOH

Factors affecting the acidity of milk:

The variation in the acidity of fresh milk may be attributed to the following:

1- Stage of lactation: Colostrum is high in acidity (TA%-0.45) but in a few days following calving the acidity of the milk becomes normal.

2- The composition of the milk: Those breeds with the higher fat% are relatively high in MSNF% and will they have the higher apparent acidities because of the increased percentage of casein and phosphates that go with the milk richer in fat.

3- Abnormal conditions within the udder: The milk from cows suffering from mastitis is frequently much lower in acidity than that produced from healthy udder.

Note: The feed consumed by the cow has no influence on the acidity of the milk produced.

Significants of the TA% test:

1- The normal TA% ranges from 0.12-0.16% with an average of 0.14%. so higher figure .i.e> 0.17% indicates lower keeping quality of milk.

2- Milk with a high percent of acid contains a large number of bacteria which get into the milk through either:

A- Poor sanitary conditions i.e lack of care and cleanliness.

B- Milk has been subjected to improper cooling (if the storage temperature exceeds 4°C).

3- TA% is valuable for use as guide in the manufacturing operations and for measuring the quality of dairy products.

Freezing point of milk (F.P.):

Water freezes at 0°C (32°F) while milk freezes at temperatures slightly lower. The range of freezing point of milk is between (-0.53) to (-0.57)°C with an average of (-0.55)°C. The Fiske cryscope is the method of choice in determining the F.P. of milk. The soluble constituents of the milk such as lactose and salts are responsible for the F.P. to be lower than that of water (solutes in liquid generally lower the F.P.). Lactose is the principle contributor to the F.P. depression of milk and is responsible for approximately 55% of the F.P. depression. The remainder of the F.P depression is due to the various salts. The most constant physical property of milk is the F.P. The secretory processes of the mammary gland are such that the osmotic pressure of milk is kept in equilibrium with that in blood. Fat and proteins have no effect on F.P. of milk. Mastitis, season and feed have no effect on F.P. of the milk. It has been show that with the addition of 1% (by volume) of water to the milk, the F.P. rises to approximately 0.0055 °C, so any reading higher than (-0.525) °C is considered adulterated milk with water. When water is added to the milk, the salts dissolved in the serum are diluted and the F.P is raised. The F.P. is used to calculate the quantity of added water to the milk. Sometime the farmer adds water to the milk and adds tasteless salts to get the F.P. back to the normal; in this case we can detect such adulteration only by using a flame spectrophotometer.

Factors affecting the Freezing point in milk:

1- Acidity of the milk: an increase in the acidity of the milk results in a lower freezing point, because the colloidal minerals dissolved by the acid and this increase the solutes in the milk.

2- Preservatives: Preservatives added to the milk will increase the materials held in solution which tends to lower F.P.

3- Species of animal: The F.P. of milk differs between species of animal and this depends upon the amount of lactose and ash in the milk of each species.

Boiling point of milk:

Milk is slightly heavier than water, and since the boiling point of a liquid is influenced by factors responsible for its specific gravity, milk boils at a temperature slightly above that of water. Water boils at 100°C (212°F) at sea level and average milk boils at 100.17°C (212.3 °F).

Effect of heat treatment on milk:

When whole milk is brought to boiling point in the air, a thin film forms on the surface which is due to the coagulation of a small amount of casein, with which are associated a small amount of calcium salts and fat. If the milk be slightly high in acid, it will curdle or coagulate when boiled. The housewife is instructed to add a pinch of soda to the milk before boiling to avoid this problem. The temperature at which milk will coagulate is closely associated with the acidity, and this is important for pasteurization and sterilization of milk. Milk must be fresh and of low acidity or it will curdle during the process of pasteurization or sterilization.

Cause of coagulation by heat:

The coagulation is due to the presence of casein and albumin. Casein is stable and its coagulation is not accomplished in fresh milk of low acidity until 131-137.8°C. With increasing acidity, casein coagulates at lower temperatures. Albumin is coagulated more readily by heat than casein in fresh milk of low acidity.

Other effect of heat:

Heating affects on the flavor and odor of the milk, the viscosity and the fat. A prolonged boiling of milk results in a brown shade of color and cooked taste, the browning color is due to the caramelization of lactose. The cooked flavor is due to the formation of sulfides or sulfhydryl compounds. Heating of milk to pasteurization temperature results in a decrease in its viscosity. The fat globules tend to form clusters, these clusters of fat globules are broken up to a large extent when milk is heated and this is responsible for the decrease in the viscosity of milk on heating.

Density and Specific gravity of Milk :

The weight of a given volume of milk can be important in quatitative analysis for composition and in packaging and sale. Density is weight per unit volume at a given temperature. For example, the density of water is essentially 1.000 at 4°C. Specific gravity, however, is the density of a substance divided by the density of water at the same temperature. The density of milk decreases as temperature is increased, but the specific gravity remains relatively constant at about 1.032. The overall density is affected by densities of the constituents.