



Definition of milk and factors affecting its composition

Definition of milk.....

Milk is a complex fluid containing many components in different states of dispersion.

- In legal terms (PFA, 1954) milk is whole, fresh, clean, lacteal secretions, obtained by complete milking of one or more healthy milch animals, excluding that obtained 15 days before or 5 days after or such periods as may be necessary to render the milk practically colostrum free and containing legally prescribed minimum percentage of fat and solids-not-fat (SNF).
- In chemical terms, it is a complex chemical substance in which fat is present in the form of an emulsion, protein and some mineral matter in the colloidal state and lactose, some minerals and soluble proteins in the form of true solution.
- Mammals secrete milk to provide nutrients required for the optimum growth of the new born. The development of the young one in all species is not uniform as such the composition of the milk secreted by these mammals also vary depending up on the nutritional needs of the young one.

Approximate composition of cow milk

Component	Average Content percentage (w/w)	Range Percentage (w/w)	Average % of Dry matter
Water	87.3	85.5 -88.7	
Solids not fat	8.8	7.9-10.0	69
Lactose	4.6	3.8-5.3	36
Fat	3.9	2.4-5.5	31
Protein	3.25	2.3-4.4	26
Casein	2.6	1.7-3.5	20
Mineral substances	0.65	0.53-0.80	5.1
Organic acids	0.18	--	1.4
Miscellaneous	0.14	--	1.1

Differences in the composition of milk from various sources

1. Buffalo milk is having the maximum fat while the fat content in sheep milk is also bit same. The fat percent in goat milk is much similar to cow milk.
2. Variation among the protein percent is also very less among these species.
3. The lactose content in human milk is characterized by having higher percent of lactose while the protein and ash content is much less when compared with other species.

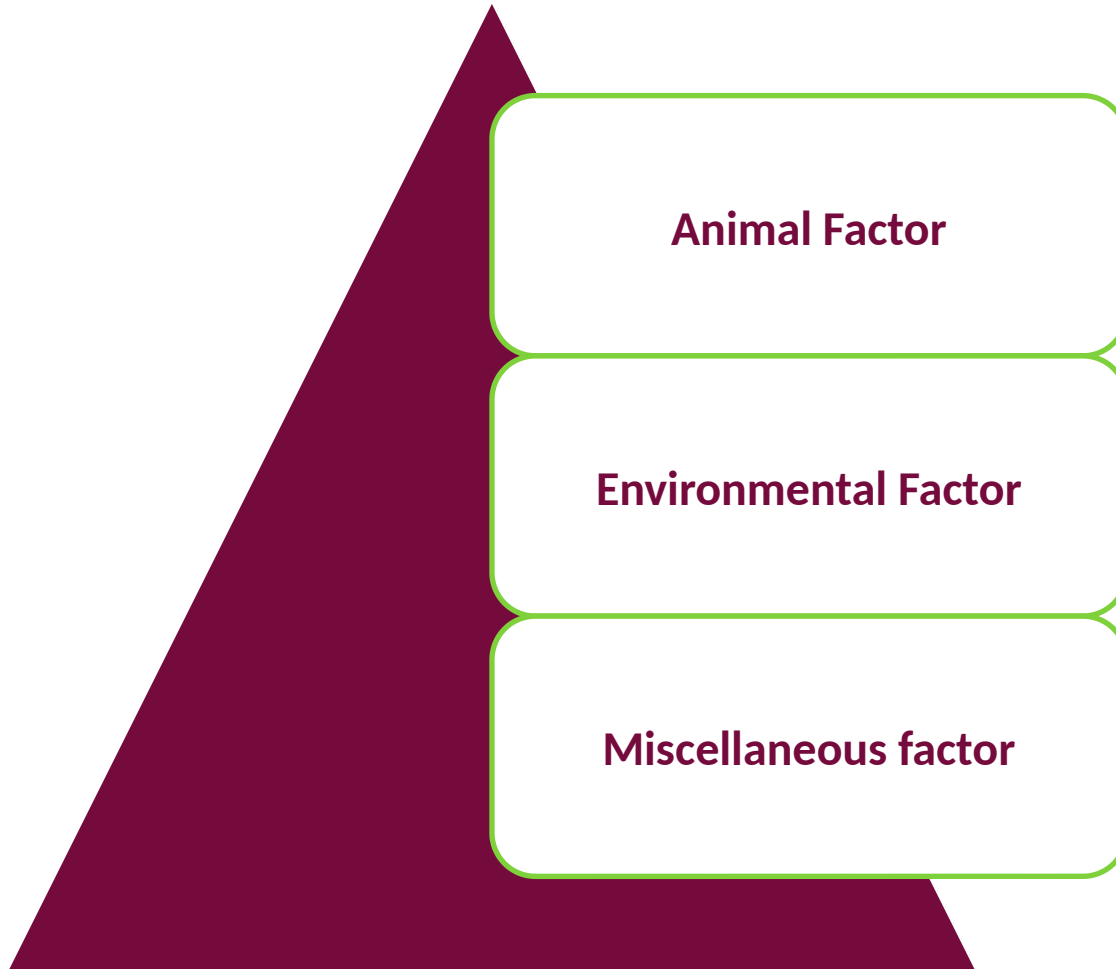
Species	Scientific name	COMPOSITION (g/100g)					
		Water	Fat	Casein	Whey proteins	Lactose	Ash
Human	<i>Homo sapiens</i>	87.1	4.5	0.4	0.5	7.1	0.2
Cow	<i>Bos Taurus</i>	87.3	3.9	2.6	0.6	4.6	0.7
Zebu	<i>Bos indicus</i>	86.5	4.7	2.6	0.6	4.7	0.7
Buffalo	<i>Bubalus bubalis</i>	82.8	7.4	3.2	0.6	4.8	0.8
Goat	<i>Capr hircus</i>	86.7	4.5	2.6	0.6	4.3	0.8
Sheep	<i>Ovis aries</i>	82.0	7.2	3.9	0.7	4.8	0.9
Horse	<i>Equus caballus</i>	88.8	1.9	1.3	1.2	6.2	0.5
Camel	<i>Camelus dromedaries</i>	86.5	4.0	2.7	0.9	5.0	0.8

Legal standards of milk (FSSAI, 2006)

Class of milk	Designation	Locality	Minimum Fat %	Minimum SNF %					
					Cow milk	Raw, Pasteurized, boiled, flavoured and sterilized	Chandigarh, Haryana, Punjab	4.0	8.5
						Raw, Pasteurized, boiled, flavoured and sterilized	Assam, Andaman and Nicobar, Andhra Pradesh, Bihar, Chandigarh Delhi, Daman and Diu, Dadra and Nagar – Haveli, Gujarat, Haryana, Goa, Himachal Pradesh, Karnataka Kerala, Lakshadweep, Maharashtra, Madhya pradesh, Manipur, Nagaland, NEFA, Orissa, Pondicherry, Punjab, Rajasthan, Tripura, Tamil Nadu, Uttar Pradesh, West Bengal	3.5	8.5
Buffalo milk	Raw, Pasteurized, boiled, flavoured and sterilized	Andaman and Nicobar, Andhra Pradesh, Dadra and Nagar – Haveli, Goa, Daman and Diu, Kerala, Himachal Pradesh, Lakshadweep, Tamil Nadu, Madhya pradesh, Manipur, Karnataka, Nagaland, NEFA, Orissa, Pondicherry, Rajasthan, Tripura	5.0	9.0					
					Goat or sheep milk	Raw, Pasteurized, boiled, flavoured and sterilized	Assam, Andaman and Nicobar, Andhra Pradesh, Bihar, Delhi, Daman and Diu, Dadra and Nagar – Haveli, Gujarat, Goa, Himachal Pradesh, Karnataka Kerala, Lakshadweep, , Maharashtra, Madhya pradesh, Manipur, Nagaland, NEFA, Orissa, Pondicherry, Rajasthan, Tripura, Tamil Nadu, Uttar Pradesh, West Bengal	3.0	9.0
	Raw, Pasteurized, boiled, flavoured and sterilized	Assam, Bihar, Chandigarh, Delhi, Gujarat, Maharashtra, Haryana, Punjab, Uttar Pradesh, West Bengal	6.0	9.0					
					Mixture of milk from different species	Raw, Pasteurized, boiled, flavoured and sterilized	All India	4.5	8.5

Factors Affecting Milk Composition

The composition of milk will show variation due to several factors. These factors are grouped into:



Animal Factors

- **Genetic:** The milk composition is basically an inherited character influenced by genes. This factor can be modified by proper planning of breeding practices. It plays a role in the quality and quantity of milk produced.
- **Species:** The composition of milk varies between species and is designed to provide different amounts of nutrients to newborns of particular species to ensure optimum growth. The faster the rate of growth, the more concentrated are the milk components needed for this growth. eg., cat milk contains about 7.0% protein since the newborn has to double its birth weight in 9.5 days, similarly the lamb will double its birth weight in about 15 days as such the sheep milk has only 4.8% protein. Human infants take substantially longer time (180 days) to double their birth weight, since the human milk has the least protein content (~ 1.0%).

➤ **Breed:** There are several breeds in domestic animals which are reared exclusively for milk production. Milk fat being the costliest component of milk, there is considerable selection among the breeds to ensure milk with a considerably higher fat content. To a considerable extent, selection of suitable breed will be based on the fat percentage in the milk produced by that breed. Much variation is not there in the remaining constituents.

Breed	Water	Fat	Protein	Lactose	Ash
Sindhi	86.07	4.9	3.42	4.91	0.7
Gir	86.44	4.73	3.32	4.85	0.66
Tharparker	86.58	4.55	3.36	4.83	0.68
Sahiwal	86.42	4.55	3.33	5.04	0.66

Average composition (% w/v) of milk from different breeds of indigenous cow

➤ **Individual cow:** Although individual animals maintain the breed characteristic of milk, there will be a variation with the individual animals. **By following good breeding practices it is possible to get higher fat %** in the individual or milch animal. A similar variation is there in the protein and lactose levels in individual animals within a given breed.

➤ **Lactation period:** Variation during the lactation period is also observed in the fat and SNF percentage during a lactation period. **Fat content is higher after parturition**, which decreases to a low during the first and second months of lactation and then gradually increases during the remaining period of the lactation. A slight decrease in **lactose %** could be observed during the last stage of lactation. Chloride content increase with the advancement of lactation, calcium concentration reduces to a minimum and further increase where, the total phosphorous declines throughout the lactation period. Natural acidity is at higher level at the beginning of lactation and will decrease to normal value during the first three months and remains fairly steady during the remaining lactation period till the last month it declines sharply.

Environmental Factors

Interval between milking: The fat content of milk varies considerably between the morning and evening milking due to shorter interval of time between the morning and evening milking than between the evening and morning milking. If cows are milked at 12 h intervals, the variation in fat content between milking would be negligible. Normally, SNF content varies a little even if the intervals between milking vary considerably.

Age: Due to several physiological changes in the individual cow with advancing age, the composition of milk produced by these animals too shows variation in their composition. As cows grow older, the fat content of their milk decreases by about 0.02 % units per lactation. The fall in SNF content is much greater.

Feeding regime: Providing the suitable and well balanced feed to milking animal, plays an important role in maintaining requisite levels of constituents in the milk produced. Underfeeding a lactating animal will only reduces the milk yield but also level of fat and SNF. Fat content and its composition are influenced more by the roughage (fiber) intake.

Disease: General health condition of individual cow plays a very important role in maintaining good milk composition. Specific diseases have great influence on the composition of milk, both fat and SNF contents reduce when animal suffers from any specific disease. Mastitis has substantial effect on milk composition; it reduces lactose content with increase in salt content of milk.

Weather: In dry months, the total yields of milk tend to decrease along with a decrease in SNF and increase in fat percentage. In wet months, there may be a decrease in both SNF and fat percentage along with or without the increase in the yield of milk which depends on the level of nutrition.

Season: There is wide variation in climate and vegetation available in different seasons of the year. Due to seasonal variation in the availability of fodder, there are changes in the milk composition. In India, butter fat content in milk is maximum in the month of May and minimum in the month of November. SNF is highest in October, and minimum in July and September. The variation in the milk production is dependent on several other factors (temperature, hours of sunshine, length of the day, exercise, rainfall, drought, pasture feeding) that are associated with the season.

Completeness of milking: During the interval between the two milking, milk will be held in gland cistern and teat cistern (space at the base of a teat or nipple into which the lactiferous ducts of a mammary gland discharge), consequently there is possibility that fat being the lightest component of milk would be moving to the surface, resulting in the variation of fat percentage in different portions of milk during the process of milking. Milk should be drawn completely from the udder during each milking so that fat is not left in the udder. The last part of the milking designated as stripping has a higher fat content as compared to the fore milk which is drawn first during the milking operation. As such completeness of milking ensures uniform quality of milk.

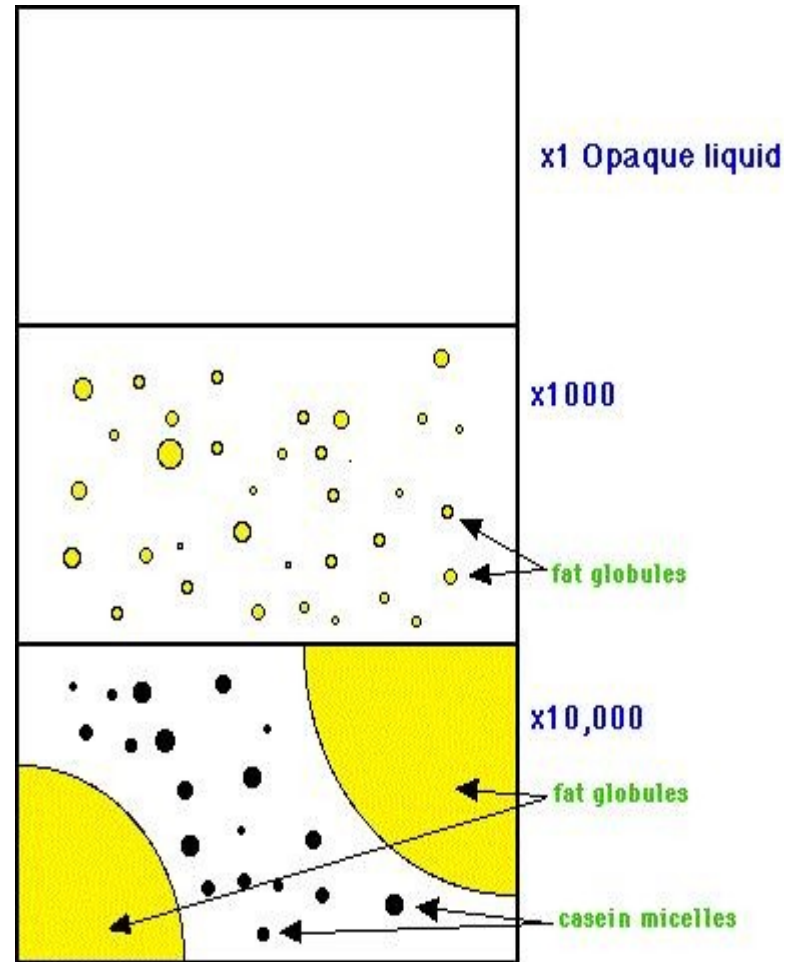
Miscellaneous Factors

Exercise: Subjecting the lactating animal to regular exercise will ensure good blood circulation through out the body and keeps the animal in good condition. In order to ensure sufficient reserve of energy such animals will eat more which would indirectly increase the milk yield. Feed consumption of the animal will increase leading to increase in milk yield along and fat percentage when compared with the period of rest.

Excitement: Hormones play an important role in the animal, especially during the milking time. Favourable conditions during milking of animals result in good milk yield. Harassment and frightening conditions (barking of dog, presence of strangers, bursting of crackers) disturbs the animal and reduces milk yield. A change in the milk composition may also be expected by these conditions.

Structure of Milk

Milk being a secretion of the epithelial cells of the mammary gland has specific interactive forces working between its components which help in maintaining the integrity of the whole system under different conditions and thereby maintaining its specific structure. The physical structure i.e., the arrangement of the components in space must also be known.



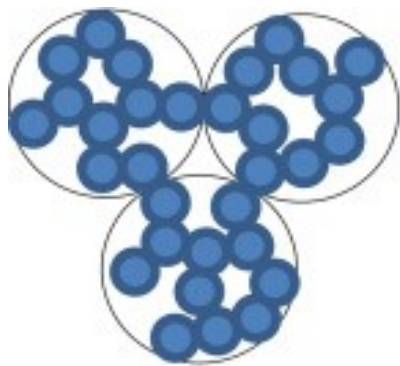
Structural Elements of Milk

Milk fat: In milk, fat exists in the form of fat globules. Fat globules are surrounded with a membrane which is derived from the apical membrane of the mammary secretory cell. Milk minus fat globules is called “**Milk plasma**”.

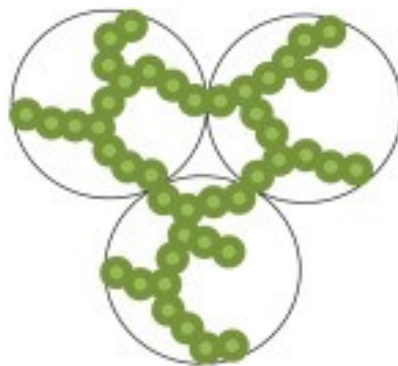
Proteins: Casein is the major protein of bovine milk and exists mainly as micellar form, whereas in human milk major proteins are whey proteins. The casein micelle consists of water, casein, salts and some minor components including lipase and proteinase. Casein micelles are built of smaller particles called sub-units or sub-micelles. Milk plasma free from casein micelles is known as **milk serum**. The liquid that is obtained on clotting of milk either with rennet or by acidification to pH 4.6 (isoelectric point of casein) is known as whey. Whey differs in its composition from that of serum in having some of the polypeptides cleaved from casein by the action of rennet. The proteins present in whey are whey proteins (globular proteins).

a. Casein micelles: Water, casein and salts along with some minor components such as lipases and proteinases constitute this structural element of milk. Casein micelles does not completely account for the casein content since some of the casein is also present in solution form. As casein binds cations (Ca and Mg ions) at the normal pH of milk (~6.6), it is called as caseinate. Calcium phosphate and small amount of citrates are the constituents associated with the casein micelle. Calcium caseinate phosphate complex is the term applicable to describe the casein micelles.

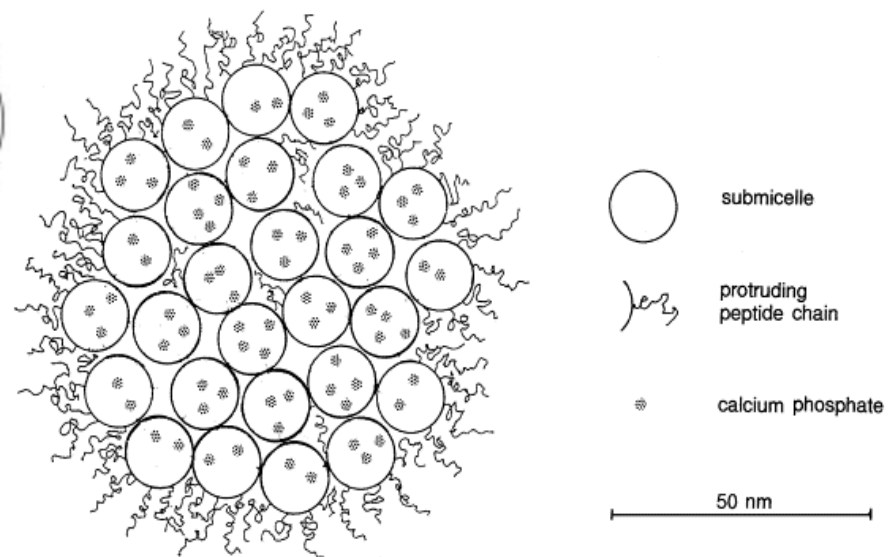
b. Whey proteins: The non-micellar proteins constitute the whey proteins.



Casein micelles



Whey protein aggregates



○ submicelle
~ protruding peptide chain
* calcium phosphate
50 nm

Somatic cells: The somatic cells consist of mainly leukocytes of various types is considered as extraneous particles although they are always present. They are about 10 μm in diameter; number is about 100,000 per milliliter and accounts for about 0.005% of the volume of milk. They contain all cytoplasmic components notably nucleic acids, enzymes and rich in catalase. In mastitic milk, the cell counts are much higher.

Fat, casein micelles and other proteins form the major structural elements of milk which are microscopic or submicroscopic in their size. Although fat is considered to be present in the form of an emulsion but it is not just a simple emulsion, because fat globules are being covered with the fat globule membrane which is derived during its biosynthesis. In addition to the fat globules some of the fat in the milk is found outside the globules.