UNIT 8 MILK COMPOSITION, ITS CONSTITUENTS AND NUTRITIONAL IMPORTANCE

Structure

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8.0 OBJECTIVES

After going through this unit, we shall be able to:

- enumerate chemical constituents of the milk;
- specify milk composition of different species;
- identify factors associated with composition of milk;
- give chemical nature of flavour and off-flavour related to milk; and
- indicate nutritional importance of milk.

8.1 INTRODUCTION

Living beings require food for various purposes like growth, reproduction, supply of energy, maintenance and recovery from diseases at different stages of their life. These functions are met from foods of different sources. Amongst different foods milk is a mixture par excellence which contribute towards nutrition of human beings. Milk is taken by the infant from birth to weaning, by the adults as well as old and sick. Some of the dairy products are also recommended as a part of the diet of such persons. The need and function of food varies as per the requirement of the individuals. Thus an infant requires food for growth and maintenance while a pregnant and lactating woman nutrient function is for the development of foetus and synthesis of milk. Food must also meet sense of taste and appetite. Milk and milk products have an unique position as a source of nutrients. Each of the milk constituent plays an important role in the life span of an individual.

8.2 MILK COMPOSITION

Mammary gland is the symbol of milk for all mammals. Milk is required by young ones for energy and growth. Milk constituents are important as human food. Utilization of milk for the manufacture of various dairy products and the problems arising during their production has led to the need to study milk composition, its constituents and factors which affect the composition of milk.

Milk is an important food for mankind and young ones of all mammals as a liquid food. Milk contains water, fat, protein, lactose, vitamins and minerals. Unravelling the composition of milk and its constituents has been a challenging problem for scientists due to its complex nature. These constituents are present in three phases viz; true solution collodial dispersion and fat-in-oil type emulsion. A knowledge of the composition of milk, lead to the understanding of physico-chemical nature of this complex biomolecule. It will also add to the knowledge needed for the preparation and manufacture of milk and its products.

i. The Gross composition of milk

Milk is the liquid secreted by the mammary gland with broad components consisting of a mixture of water, fat, proteins, lactose, minerals and vitamins as the nutrient. On an average cow milk contains 87 per cent water, 3.9 per cent fat, 4.9 per cent lactose, 3.5 per cent protein and 0.7 per cent minerals and vitamins and other minor constituents. Chemical composition of milk of different species varies considerably (Table 8.1). The composition of milk varies with the species to ideally suit the need of new born infants. However, milk from cow, buffalo and goat ideally meet the requirement of human beings as liquid milk or its products.

ii. PFA definition of milk

There are several definitions for milk. As per PFA (1976) milk has been defined as the lacteal secretion obtained by the complete milking of one or more healthy milch animals, which is free from colostrum. Cow milk shall contain not less than 8.5 per cent of solids-not-fat and not less than 3.5 pre cent of milk fat while buffalo milk shall contain not less than 9.0 per cent solids-not-fat and not less than 6.0 per cent milk fat.

Table 8.1: Chemical Composition of milk of different Species

	Name	Water %	Total Solids %	Fat %	Lactose %	Protein %	Mineral %	SNF (Solid Not Fat) Minimum %
1	Cow	87.2	12.8	4.0	4.7	3.4	0.7	8.8
2	Buffalo	83.5	16.5	7.2	4.8	3.8	0.7	9.3
3	Human	87.4	12.6	4.3	6.8	1.25	0.2	8.3
4	Goat	86.9	13.1	4.0	4.6	3.7	0.8	9.1
5	Sheep	81.5	18.5	8.6	4.7	4.5	0.7	9.9
6	Mare	90.1	9.9	1.7	5.7	2.2	0.3	8.2
7	Donkey	91.5	8.4	0.6	6.1	1.4	0.3	7.8
8	Camel	86.5	13.5	3.0	5.6	4.0	0.8	10.5
9	Elephant	67.8	32.2	19.5	8.8	3.2	0.6	12.7
10	Dog	75.5	24.5	9.5	3.3	11.1	0.6	15.0
11	Cat	82.1	17.9	3.3	4.9	9.0	0.6	14.6

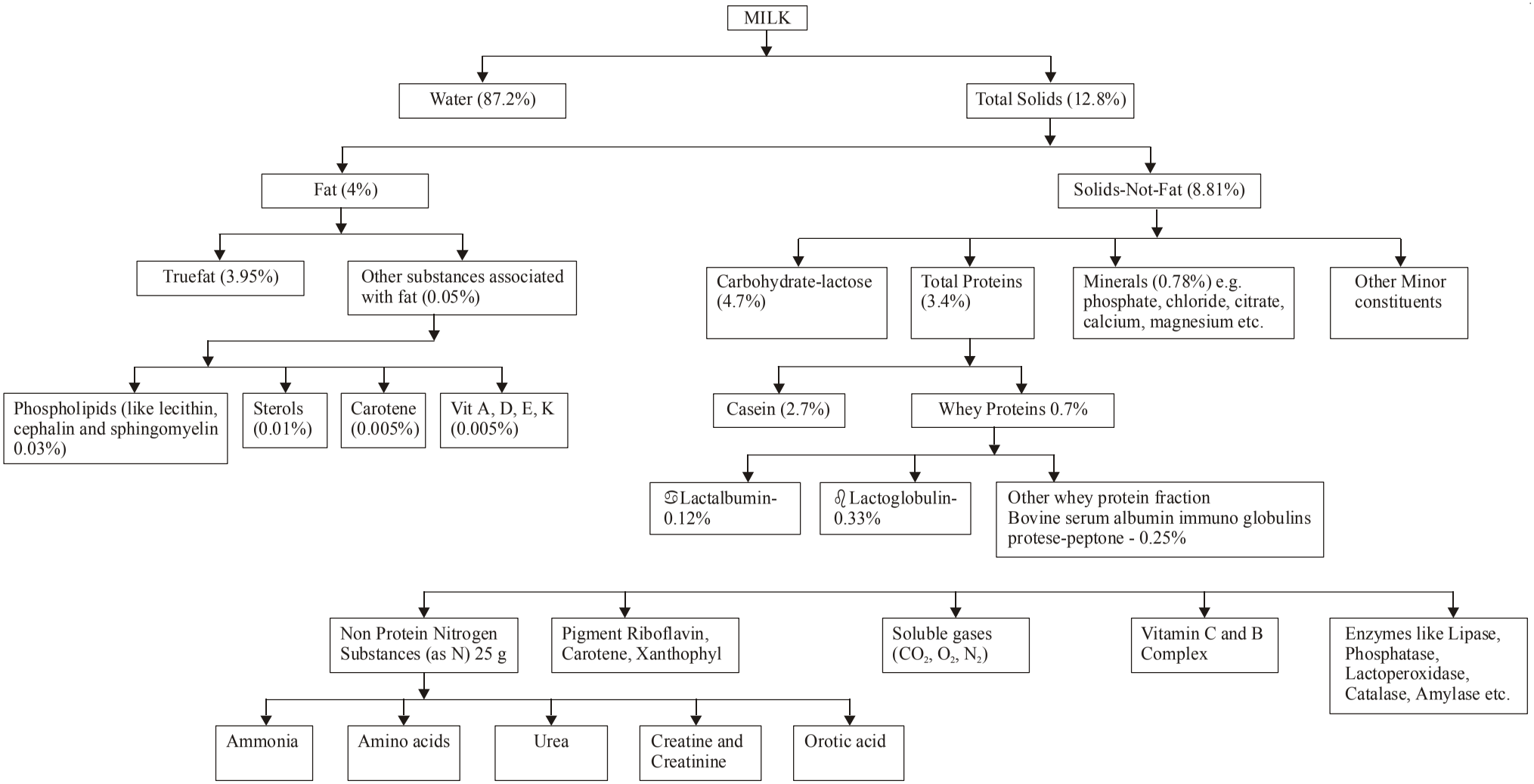

Fig 8.1: Distribution of Constituents of cow milk

Check Your Progress 1

1. Give the composition of cow and buffalo milk.

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2. Name the highest component other than water present in human milk.

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3. State the level of protein in sheep milk.

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8.3 MILK CONSTITUENTS

Milk is a complex mixture of various constituents. On keeping at room temperature milk separates into fat as cream, curd or casein and whey. Curd and whey separates on curdling of milk. However, the constituents of milk include water, fat, proteins, lactose, minerals, enzymes and vitamins. Distribution of constituents of cow milk is given in the Fig 8.1.

A detailed study of the constituents of milk is essential to understand the nature of milk, its physico-chemical characteristics and nutritive value. The constituents have an important role in the preparation of milk products. Study of each constituent helps in understanding its chemical microbial and technological behavior.

Physical States of Constituents of milk

The main constituents of milk, namely, fat, sugar, protein, minerals, vitamins and other minor constituents are present in three states. The three physical states are true solution, colloidal dispersion and fat in oil-type emulsion follows:

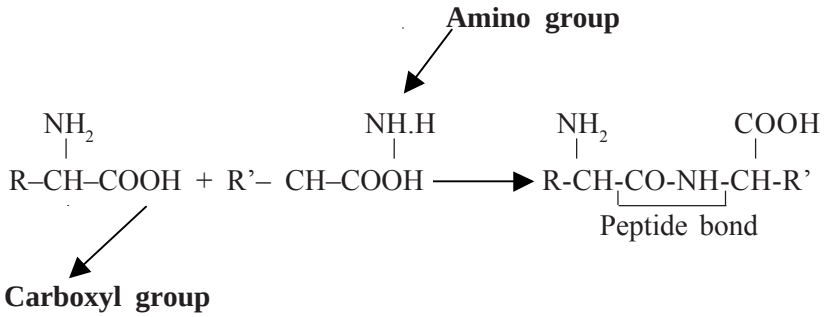
There are always a state of equilibrium between colloidal state and true solution in normal milk.

i. Milk Proteins

Proteins are present in milk in colloidial state. Important proteins found in milk are casein and whey proteins. Description of these proteins is presented here:

i) **Casein:** Casein is the major proteins which contribution at 80% protein. It is present in milk in colloidal state in the form of Calcium caseinate phosphate complex. The micellar particles of casein are spherical in nature and exist in milk as distinct particles. Each micelle of casein is bridged with various submicelles. The submicelles within casein micelle are held together by calcium phosphate by an ester linkage with the serine hydroxyl group. The calcium phosphocaseinate are rather large in size, as seen by electron microscope ranging in size between 30-300 millimicrons in diameter.

Definition of Casein: Casein may be defined as phosphoprotein obtained from raw milk at pH 4.6 at 20^0C. Casein is made up of amino acids forming a polymeric chain through a peptide bond $(-CO-NH_2-)$. This linkage is established by reaction of an amino and a carboxyl group.



With difunctional units such as the amino acids, long chain polymers can be built in this way.

Heterogeneity of Casein : Based on its primary structure, electrophoresis, chromatography and solubility in salts such as urea, casein is classified in the form of its fractions namely,

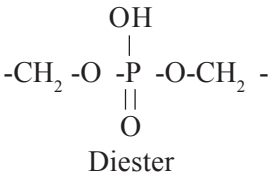
a_{s1} – Casein
a_{s2} – Casein
b – Casein and
k – Casein

These main fractions are themselves variable because of genetic polymorphism involving deletion or substitution of amino acids within the polypeptide chain of each fraction.

β

Elementary Composition: Casein contains the following elements (in percent) – Carbon 52.6-54.0, Hydrogen 6.75-7.10, Nitrogen 15.51-15.91, Sulphur 0.71-0.83 and Phosphorus 0.71-0.85.

Since casein is a phosphoprotein the phosphorus is bound chiefly if not entirely in ester linkge with the - OH group of amino acid serine or threonine



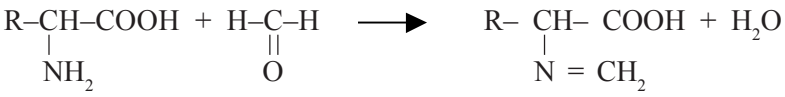
Diester

Electrical Properties: The isoelectric point of casein is pH 4.6 i.e. at this pH it has a zero net change. Above this pH it carries a negative charge while below this pH it is positive in nature. Thus at the pH of milk (pH 6.6 to 6.8), casein carries negative charge and, therefore, migrates towards anode in an electric field.

Solubility: Both α -and -casein are insoluble at isoelectric point (pH 4.7 and 4.9) but dissolve readily on either side of pH, a-casein is less soluble at pH 4.2 at 2^0C while b - casein is more soluble at pH 4.2 at 2^0C causing their separation. Casein also binds calcium ions above isoelectric point causing aggregation of casein, which lowers its solubility.

Other Properties : Casein also posseses other properties such as optical rotation, suggesting globular nature, oxidation and reduction due to its amino acids, and reacts with formalin/ formaldehyde. This reaction with formalin takes place through

amino or amide groups of amino acids of casein. During this reaction with formalin an equivalent amount of protons (H^+ions) are released which is then titrated against an alkali. The amount of proton released are equivalent to the amount of protein present. This is the basis for estimating protein in milk quickly by titration with NaOH.



Amino acid Formaldehyde → Complex

ii) **Whey Proteins:** Lactalbumin and globulin fractions of whey proteins are two proteins together which form about one-eighth of the total protein of milk and are described as soluble protein. Both albumin and globulin are soluble in milk/ whey but they differ in that while albumin is soluble in water, globulin is insobule in water but soluble in dilute salt solutions. Both are coagulated by heat, the extent of which is governed by temperature and time of holding, salt concentration and pH of the solution (e.g., pH 4.5). Whey proteins are the native proteins present in whey or serum and are a constituent of whey, which is prepared after removal of casein through acidification at pH 4.6 or by rennet action during preparation of cheese. b-lactoglobulin is the major whey protein of milk. b-lactoglobulin is globular in nature. It has a molecular weight of 36,000 daltons with an iso-electric point of 5.2. It is a heat labile protein and gets denatured on heating. It is soluble in salt solution. It has a high nutritive value. It possess free – SH group in its structure through amino acid cysteine.

Alpha-lactalbumin is the second most abundant whey protein after b lactoglobulin. It is rich in human milk. This protein is involved in the bio-synthesis of lactose. It has a molecular weight of 16,000 daltons with an iso-electric point of 4.2. It contains no phosphorus or carbohydrate. This protein is very rich in the amino acid tryptophan and sulphur containing amino acids cystine and cysteine. Due to the presence of essential amino acids this protein is nutritionaly important whey protein.

Table 8.2 Properties of whey proteins

Property	b-Lacto globulin	a-Lactalbumin	Blood serum albumin	Lactoferrin
Molecular weight	36,000 Daltons	16,000 Daltons	65,000 Daltons	80,000 Daltons
Isoelectric point	5.18	4.2	4.72	8.2

iii) **Immunoglobulin:** Globulin of milk and blood are identical. In colostrum and milk both are present but globulin in the form of immunoglobulin is found in much higher amounts in colostrum. In milk, globulin is present to the extent of only 0.1 percent, while in the colostrum it is 6 per cent. This concentration is so high that it causes coagulation of colostrums on heating. This property of colostrum being lost as the globulin declines to the normal level in milk. Both albumin and globulin proteins possess a high nutritive value and supply all essential amino acids. Moreover, albumin rectifies the low sulplur content of

casein in the form of alpha - lactalbumin and beta - lactoglobulin in normal milk. Thus they are complementary in that the value of the three milk proteins is larger in presence of each other than when measured separately. Molecular weight of immunoglobulins is very high ranging between 1,80000 to 8 lac daltons.

Traces of certain other proteins are also present in milk. These include proteose-peptone, iron-containing protein lactoferrin, fat globule membrane protein, lactollin, free secretory component, folate and vitamin B_{12} binding protein along with various milk enzymes, which are more than 30 in number.

iv) **Non protein nitrogenous substances:** Milk contains various nitrogen containing substances, which are not true protein. Their amount is 5 percent of the total nitrogen found in milk. These are popularly referred as NPN or non protein nitrogenous constituents of milk. They are present in four forms as (a) amine (e.g., ethanol amine, choline) (b) amino acids (e.g., free amino acids such as lysine, leucine, etc) (c) amino acid derivatives (e.g., creatine, creatinine) and (d) other compounds (such as morphine and milk oligosaccharides). NPN varies from season to season and has no biological value as that of protein.

v) **Enzymes in Milk:** Enzymes are organic catalyst, which are found in plant and animal cells. They bring about most complex chemical reactions but they themselves do not enter into chemical change. They are colloidal and proteinous. They are classified as per the chemical changes they bring about, such as hydrolase (hydrolysing enzymes), oxidase (oxidizing enzymes), reductase (reducing enzymes). They are also classified on the type of substrate they attack e.g., protease (protein splitting enzymes), lipase (fat splitting enzymes), amylase (starch splitting enzymes) etc.

Enzymes are susceptible to heat, light and pH changes. There are substances, which enhance the activity of various enzymes and are known as co-enzymes and those, which inhibit the activity, are called as anti-enzymes.
Enzymes in milk occur in 4 phases. They are:

- water soluble
- casein bound
- lipid bound and
- present in microsomal particles
- These enzymes are in a state of equilibrium in milk and can change their state due to agitation, homogenization, heating, etc.

a) **Peroxidase:** Peroxidase enzyme liberates oxygen from hydrogen peroxide. Lactoperoxidase is the principle enzyme present in fresh milk. Activation of lactoperoxidase result in enhancing the keeping quality of raw milk for longer period. It is destroyed at a temperature above 80^0C.

b) **Amylase (diastase):** This enzyme hydrolyses starch to dextrin. It is present in milk in small amount. It is destroyed at 60-65^0C.

c) **Lipase:** It is a hydrolytic enzymes. It hydrolyze fat into the corresponding fatty acids and glycerol. It causes butyric or hydrolytic rancidity in milk, cream, butter, ghee and enhances acidity. It is destroyed on heating at 63^0C for 20 minutes.

d) **Catalase:** Catalase decomposes hydrogen peroxide into oxygen and water. It is present in small amount in milk. However, on contamination of milk its concentration increases in milk. It is destroyed when heated above 90^0C for 20-25 minutes.

e) **Phosphatase:** This enzyme hydrolyze phosphoric acid esters. During pasteurization of milk this enzyme is destroyed. This enzyme is thus used as a marker to check proper pasteurization of milk and milk products.

f) **Proteases:** These are proteolytic enzymes and hydrolyze protein into simpler compounds such as proteose, peptone and amino acids. These enzymes are

involved in the hydrolysis of milk proteins i.e. casein and whey proteins. Proteases enzymes are destroyed at a heating temperature of 80^0C.

g) **Reductases:** These enzymes help in reduction of certain organic compounds. They reduce methylene blue added to milk and make it colourless.

h) **Lactases:** They hydrolyze lactose into glucose and galactose. The principle enzyme is beta glycosidase. The above emzyme hydrolyze lactose, which is finally converted into lactic acid.

ii. Milk Carbohydrates

The principal sugar of milk is lactose, which is present to the extent of 4.8-5.0 percent in milk. In addition milk also contain traces of bound carbohydrates. Human milk is a rich source of lactose and oligosaccharides. Human milk contains about 6.3-7.0 percent lactose and between 0.3-0.6 percent oligosaccharides.

Lactose: Lactose is the sugar which is found exclusively in the milk of mammals. Lactose is present in true solution. On crystallization lactose crystallizes with one molecule of water of crystallization ($C_{12}H_{22}O_{11}.H_2O$). These crystals are gritty in nature and sometime give gritty or sandy taste to some milk products like concentrated milk and ice-cream.

Structurally lactose consists of glucose and galactose molecule which together form the lactose molecule. Thus lactose is a disaccharide because it is made up of two monosaccharides. On hydrolysis of lactose by the enzyme lactase found in small intestine, lactose splits into glucose and galactose.

$$C_{12}H_{22}O_{11}+H_2O \xrightarrow{\text{Lactase}} C_6H_{12}O_6+C_6H_{12}O_6$$

Mineral acids such as hydrochloric acid also possesses the hydrolyzing capacity to split lactose into its two sugar units viz. glucose and galactose. Certain yeasts and enzymes have the ability to ferment lactose to alcohol and lactic acid which impart acid or alcoholic taste to fermented milk products.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}}+HOH \longrightarrow \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6}$$

$$2C_6H_{12}O_6 \longrightarrow 4\ \underset{\text{Lactic acid}}{CH_3CHOHCOOH}$$

The conversion of lactose to lactic acid is favoured by microorganisms as lactose is a good substrates for their activity. This causes sour taste to milk. At an acidity of 0.18 to 0.20 per cent milk curdles on heating. Lactose is faintly sweet, about one-sixth the sweetness of cane sugar.

Lactose is a reducing sugar due to the presence of a free aldehyde group. It thus reduces fehling solution. Lactose is insoluble in alcohol and ether but is soluble in hot acetic acid. On oxidation lactose is oxidized to formic acid or carbonic and oxalic acid depending upon the oxidizing agent used. On heating above 150^0C lactose turns yellow and at 175^0C it turns brown and form caramel. Slight burning and cooked milk odour is due to caramel, though milk and milk products are never treated to such high temperatures under ordinary processes. Thus individual milk constituents have different property rather than when they are present in a complex system like milk.

Lactose is involved in Maillard reaction with ammonia, amino acids or amines forming brown coloured pigments as complexes. Lactose helps in assimilation of calcium and phosphorus from small intestine and has a beneficial effect.

iii. Milk Fat

In milk, fat is present in the form of fat globules with an average size of 3 micron. If cool raw milk is kept for sometime without mixing there is tendency for the fat globules to cluster and rise at the surface forming cream layer. However, these globules are independent due to the presence of a protective fat globule membrane layer. Fat is distributed in continuous aqueous phase as an oil-in-water type emulsion. The membrane prevents the merging of fat globules and formation of a continuous fat phase.

Nature of protective fat globule membrane layer: On examination of the protective fat globules layer it is found that a variety of substances are present in it. These include protein, phospholipids, phosphatase, complex of vitamin B_{12} binding proteins and a complex of riboflavin- phosphoric acid protein. There are also metals like copper, iron and zinc. In the presence of copper it causes oxidation of fat.

Physico-chemical nature of milk lipids: Milk lipids are present in three phases in milk, namely, the fat globule, the membrane surrounding the globule called fat globule membrane (FGM) and the milk serum. Fat globules are entirely made up of triglycerides coated with FGM containing complex lipids, phospholipids and proteins (Table 8.3).

Table 8.3: Various lipid material present in milk

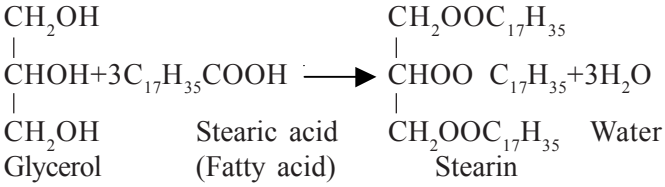
Constituents	Location in milk
Triglycerides	Fat globules
Phospholipids (lecithin, cephalin and sphingomyelin	Fat globule membrane and serum
Sterols (cholesterol)	Fat globule, FGM and serum
Free fatty acids (various)	Fat globules and serum
Waxes	Fat globule
Squalene	Fat globule
Fat soluble vitamins such as Vitamin A, Carotenoids, Vitamin E, Vitamin D and Vitamin K	Fat globule

Source: Principles of Dairy Chemistry by Jennes & Patton

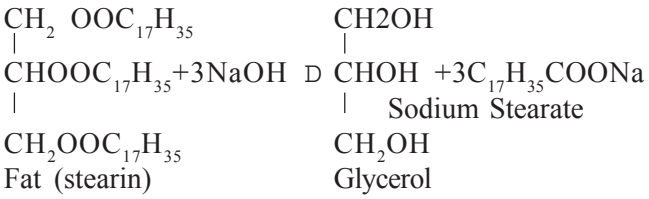
Physical properties of milk fat: The physical properties of the milk fat are determined by the nature and proportion of its consitituents. The colour varies from yellow (due to carotene) to whitish light blue tinge due to bilirubin. The melting and setting of the fat takes place over a considerable range of about 5^0C. The ranges are 28-33^{0}C and 24-29^{0}C as the melting and setting points, respectively. This shows that fat is made up of several components which is a mixture where different constituents at different temperatures have their own melting point and other physical properties.

Milk fat has a specific gravity range of 0.936-0.946 at 15^0C. Milk fat has a refractive index of 1.459-1.462 at 15^0C. It is slightly soluble in ethanol but is readily soluble in hot amyl alcohol.

Chemical Properties of Milk Fat: True fats are glyceride esters of higher fatty acids.



During hydrolysis of fat it is resolved into its components i.e. glycerol and the corresponding fatty acids. This hydrolysis occur naturally by the enzyme lipase. The hydrolysis can be brought about also by superheated steam or alcoholic NaOH.



All fats react in this manner but differ only in the number and relative proportion of fatty acids that are united to glycerol. If milk fat is treated in the above manner, about 16 fatty acids are obtained, some of them are soluble in water but most of them are insoluble and appear as white precipitate oleic, polmitic, butyric, stearic and myristic acids are the five major fatty acids.. While many of these fatty acids are odourless and almost tasteless some of them such as butyric acid possess strong odour. The libration of butyric acid leads to rancidity of fat caused by hydrolysis.

Milk fat also contains oleic and palmitic acids like other fats representing one-third and one-fourth of total fatty acids, respectively. However there are the minor constituents, which distinguish milk fat from other fats. Nearly 43 percent of the milk fat is unsaturated which give chemical activity to fat.

With glycerol about eighteen compounds are formed if fatty acids are attached. But the glycerides present in milk fat are compounds of glycerol with two or even three different fatty acids. Thus, a large number of compounds are present in milk fat.

iv. Milk Salts

In milk, salts are represented by the "non-combustible matter" known as "ash". The ash constitute the mineral matter of milk which is present to the extent of 0.7 per cent. The ash content is normally constant in milk. A higher value indicate an abnormal condition of the mammary gland. The important salt constituent present in milk ash are calcium, phosphorus, magnesium, sodium, potassium chloride, citrate and sulphur. Calcium and phosphorus are the pre-requisite for bone formation in the body. Milk is a very rich source of calcium. Average content of milk salts present in milk is presented below: (Table 8.4).

v. Milk Vitamins

Milk is a very rich source of most of the vitamins except vitamin C. Almost all the vitamins are present is milk. Milk contains both fat soluble and water soluble vitamins (Table 8.5).

Table 8.4: Salt contents in Milk

S.No.	Constituents	Average content mg/100 ml
1.	Sodium	50
2.	Potassium	145
3.	Calcium	120
4.	Magnesium	13
5.	Phosphorus (total)	95
6.	Chloride	100
7.	Sulphate	10
8.	Carbonate (as carbon dioxide)	20
9.	Citrate (as citric acid)	175

a) Fat soluble vitamins
   i) Vitamin A
   ii) Vitamin D
   iii) Vitamin E
   iv) Vitamin K

b) Water soluble vitamins
   i) B_1 (Thiamine)
   ii) B_2 group- This group consists of Riboflavin, Nicotinic acid, Pyridoxine, Pantothenic acid, Biotin, Vitamin B_{12} and Folic acid
   iii) Vitamin C or Ascorbic acid.

Table 8.5: Quantity of vitamins present in milk

Vitamins	Amount
Fat Soluble:	
Vitamin A	20 I.U. per g of fat
Carotene	5 mg/g of fat
Vitamin D_3	1 I.U. per g of fat
Vitamin E	28 mg/g of fat
Vitamin K	Traces
Water Soluble:	
Vitamin B_1	37 mg
Riboflavin	140 mg
Pantothemic Acid	400 mg
Nicotinic acid	63 mg
Pyridoxine	37 mg
Biotin	1.6 mg
Vitamin B_{12}	0.3 mg
Folic acid	0.3 mg
Ascorbic acid (Vitamin C)	2.0 mg

Source – Ling, E.R. (1956) Volume 1

Note 1 mg= one millionth of a gram

Though all the above mentioned vitamins are present in milk, but those present in appreciable amounts to make milk a valuable source are vitamin A and B_2 group as far as human nutrition is concerned.

Check Your Progress 2

1. Name the three states in which constituents of milk are present.

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2. Give the range of size of casein micelles.

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3. State the pH at which casein coagulates from milk.

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4. Give the molecular weight of beta lactoglobulin.

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5. Which protein is present in highest amount in colostrum?

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6. True fats are made up of glycerides of fatty acids. True or False.

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8.4 FACTORS AFFECTING THE COMPOSITION

The main constituents of milk are fat, protein, lactose and ash. The proportion of these constituents varies with type of milk. This variation in composition of milk is due to several factors such as species, breed, stage of lactation, feeding, etc. Cow, buffalo, goat and sheep milk are often consumed and have been studied in detail. Some of the factors which affect the composition of milk are:

1. **Species:** The milk from various species of manmals have different composition (Table 8.6). This variation in milk composition is due to species effect.

Table 8.6: Difference in milk composition due to species

Species	Water %	Fat %	Sugar %	Protein %	Ash %
Cow	87.54	3.71	4.70	3.31	0.76
Goat	85.58	4.93	4.78	4.11	0.89
Buffalo	82.90	7.50	4.70	4.10	0.80
Human	88.50	3.30	6.80	1.30	0.20

2. **Breed:** Like species composition of milk is also determined by breed. Exotic as well as indigenous breeds differ somewhat in their composition. Within the different breeds fat is the major constituent, which is affected most. This variation in fat content in different breeds is evident from the data in Table 8.7. Generally milk containing a higher percentage of fat is also rich in solids not fat as vice versa Table 8.7, 8.8 and 8.9.

Table 8.7: Variation in the composition of milk of exotic breeds

Breed	Fat %	Protein %	Lactose %	Ash %	Total solids %
Holstein	3.55	3.42	4.86	0.68	12.50
Brown Swiss	4.01	3.61	5.04	0.73	13.41
Ayrshire	4.14	3.58	4.70	0.68	13.10
Jersey	5.18	3.86	4.94	0.70	14.09
Guernsey	5.19	4.02	4.91	0.74	14.87

Adopted from- Principles of Dairy Chemistry, R.Jenness & S. Patton 1959

Table 8.8: Variations in composition of milk amongst Indian breed of cows

Breed	Fat %	Protein %	Lactose %	Ash %	Total solids %
Gir	4.73	3.32	4.85	0.66	13.30
Red-Sindhi	4.90	3.42	4.91	0.70	13.66
Sahiwal	4.55	3.33	5.04	0.66	13.37
Tharparkar	4.55	3.36	4.85	0.68	13.25
Crossbred	4.50	3.37	4.92	0.67	13.13

Table 8.9: Variation of composition of milk according to the breed of buffalo

Breed	Fat %	SNF
Murrah	6.8	10.1
Jaffarabadi	7.3	10.1
Surti	8.4	10.3

Source: Indian Dairy Products, Rangappa and Achaya

3. **Individuality of Animal:** Under identical condition of management and feeding, within the same breeds, individual variations in the composition of milk always exist. These may affect milk components like fat or protein, which may be high or low. These variations have been attributed to the individuality of the animal.

4. **Milking Intervals:** Milking intervals also affect the composition and yield of milk. As a rule longer the milking interval lower is the fat content, which is compensated with a higher milk yield. However, variation in the fat content of both the individual and herd milk between the morning and evening bulk milk samples occur (Table 8.10).

Table 8.10: Variation in fat content of milk due to the time of milking (fat percent)

Time of milking	Red Sindhi	Gir cow	Buffalo
Morning	6.0	6.0	7.1
Evening	6.3	6.2	7.9

Source: Indian Dairy Products, Rangappa and Achaya

5. **Milking Efficiency:** Milking efficiency is a very important factor to obtain high milk yield and fat. As the udder is emptied during milking fat also increases. No appreciable differences other than in milk fat have been found between fore milk and strippings. The fore-drawn milk contain about 1 to 2 percent fat and as the milking progresses the fat content increases upto 6 percent or more in strippings. However, there seems to be a general relationship between fat percentage and solids-not-fat. The first portion is poorest in fat but richest in solids-not –fat but later portion is poorest in S.N.F. and vice versa (Table 8.11).
6. **Stage of Lactation:** The composition of milk varies with lactation. The first secretion after parturition, namely the colostrum is totally different from milk in its composition and general properties (Table 8.12). Colostrum is very thick in nature with a high viscosity. It has a high concentration of immunoglobulin, lactoferrin, chloride and low lactose content. Its fat content may be higher or lower than that of milk. Colostrum from different cows and buffaloes varies much more in composition than does milk. With successive milking, the composition rapidly approaches that of milk, and the variability decreases.

Table 8.11: Variation is composition of different portions of milking

Portions	Fat %	S.N.F %
1	1.04	8.64
2	1.42	8.63
3	3.02	8.57
4	4.40	8.37
5	5.32	8.15
6	7.63	7.77

Source: Indian Dairy Products, Rangappa and Achaya.

Table 8.12: Composition of colostrum

Colostrum	Total Solid %	Fat%	Total Protein %	Lactose %	Ash %	Specific Gravity
Ist milking	24.55	3.89	16.76	2.50	1.33	1.0604
2nd milking	18.00	3.84	9.33	3.52	0.97	1.0437
3rd milking	16.79	3.11	7.06	3.85	0.96	1.036
4th milking	15.21	3.82	6.17	4.23	0.88	1.0372

The transition from colostrum to a composition within the range of variation of normal milk is complete in about 4 days, the protein content being slowest to complete the transition. The yield of milk increases to a maximum in early lactation and than falls to normal. When yield of milk increases, fat and solids-not-fat decreases and vice versa. This decrease is between 0.2 to 0.4 percent. The only change in lactose percentage attributable to stage of lactation is a slight decrease towards the end.

Because of low lactose concentration the osmotic pressure also remain low and in order to rectify the low osmotic pressure, the concentration of chlorides, sodium and soluble non-protein nitrogenous compounds, which restores the osmotic pressure to its normal level increases. Due to an increase in calcium towards the end of lactation it is a common experience that a salty taste may be detected in the milk of cows in advanced lactation. Calcium decreases to a minimum concentration and then increases, whereas total phosphorus remains constant throughout.

7. **Feeds and Nutritional Level:** Excessive feeding of fooder and concentrate is known to slightly increase solids-not-fat content in milk. Excessive protein in the feed does affect the protein content but may increase non-protein nitrogen content and sometimes fat. On feeding on pastures solids-not-fat content increases. The lactose content is not changed.

   Rations low in roughages lower the fat content by 0.5% with no change in milk yield. Additional feeding with palm oil, butterfat, lard and coconut oil increases the fat percentage while cod liver oil lowers the same. Food fats modify the composition of milk fats to a limited extent. Feeding of minerals such as calcium and phosphorus does improve their level in milk.

8. **Season:** Seasonal variations are directly related to temperature, humidity, sunshine and drought. In summer months drop in milk yield occur with slight decrease in fat content. However, vitamin D content increases due to exposure to sunlight. During rainy season when green fodders are available in plenty carotene and riboflavin level increases. During the period of drought the solids-not-fat content decreases while there is no change in fat percentage. Fat content is highest in May and minimum in November while S.N.F is highest in October and lowest in July and September.

9. **Disease:** Disease adversely affect the composition. During infection of the udder with mastitis or foot and mouth disease there is lowering of lactose and casein. There is an increase in chloride content, increase in soluble nitrogen and reduction in natural acidity. There is also an increase in ash content.

10. **Age of the Animal:** With the advancement of age there is a slight decrease in fat content. An irregular decline in S.N.F also occurs. Within S.N.F, lactose and casein are the main components, which are affected. Maximum milk yield in milk occur from fifth to the ninth month of lactation. Age factor is highly effective with advancement of lactation.

11. **Hormones:** Injections of hormones such as prolactin and oestrogen is known to have a favourable role in enhancing milk production, fat and solids-not-fat content. However, excessive dose has a negative effect with depression of milk. These hormones enhance the metabolic activity of the body but excessive dose have a deleterious effect.

12. **Heat or Oestrum:** During the heat period the yield of milk and fat is slightly affected. This is due to the excitability and nervousness of the animal due to heat or hormonal secretion. Variations in fat occur due to the holding up of the milk by the animal.

13. **Gestation:** During the gestation period especially towards the end of lactation changes in milk composition occures. These variations are reflected in solids-not-fat content, which is increased. The composition is affected from fourth month onward.

Check Your Progress 3

1. Amongst cow, buffalo, goat and human, name the species which has lowest percentage of protein.

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2. Explain how colostrum milk is different from normal milk?

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3. Give in brief role of age in affecting the composition of milk.

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8.5 FLAVOURS AND OFF-FLAVOURS RELATED TO MILK

Flavours of foods can be divided into two categories. Natural, good or normal flavour which are desirable, or essential flavours. The other category is off-flavour which are undesirable and are not natural or normal flavours.

For consumer acceptance of any food including milk, flavour is of primary importance. Even if the food is wholesome, nutritious, attractively packaged, reasonably priced, but if its flavour is poor it will be rejected by the consumers. Milk and milk products are in the top list of foods where flavour plays most important role. Right from production of milk at the farm to the point of processing of milk into milk and milk products needs proper handling of milk to avoid flavour contamination and deterioration. Thus knowledge of flavour is indispensable in the production of milk and milk product that are consistently acceptable to consumers.

Studying flavour involves study of three fields together. These include dairy technology, chemistry and physiology. Dairy technology involves control of flavour, chemistry deals with micro-chemical changes involved in flavour development including the chemistry of compounds involved. Physiology, deals with sensory evaluation which includes odour and taste of milk and milk products.

The nature of flavours: Three basic sensory aspects are involved in flavour. They include olfactory, gustatory and tactual components. On tasting, food vapours go into the olfactory area which is related with odour of milk. Taste is concerned with sensation in the mouth and tongue. These include sweetness, sourness, saltiness and bitterness. Sensation is detected by taste buds. Actual sensation gives an index of the milk feels in the mouth. This aspect deals with the feeling aspects such as tender, grainy, etc.

Measurement of flavour: Flavour is measured psychometrically and by chemical analysis. Chemical analysis only shows the nature of component responsible for flavour. However, chemical methods cannot evaluate like or dislike of flavour. They can be differentiated only by psychometrically as stated above.

Flavour identification: Compounds responsible for a given flavour needs identification. This is essential so that off flavours may be prevented and desirable flavours can be preserved.

Flavour components are present in minute amount in (parts per million or parts per billion). These components can be isolated and identified chromatographically involving TLC (Thin Layer Chromatography), GLC (Gas Liquid Chromatography), HPLC (High Pressure Liquid Chromatography) and often combined with mass spectrophotometery. Infrared (IR) is also used in flavour analysis.

i. Flavour of milk

Flavour of milk can be divided into two categories, normal and natural flavour that are desirable. Milk should be free from oxidized, rancid, feed/weed, unclear, malty and other off flavours.

On tasting milk, one finds milk sweet and slightly salty. Normally it is neither bitter nor sour. However, these variations differs with individuals. Some detect milk as sweet, others flat and still others a slight salty. Sweet-salt taste varies with individuals. Milk has sweet taste due to the presence of sugar lactose (4.8-5.0%). Salty taste is observed in mastitis milk due to its high chloride content. This is also true for late lactation milk.

Normal milk has a sweet characteristic flavour, which is faint in nature. At present it cannot be said conclusively what compounds cause natural flavour of milk. However, some low weight compounds definitely contribute to the flavour of milk though they are present in trace amount. They include acetone, acetaldehyde, butyric and certain other free falty acids contributing towards the flavour of milk. A high predominance of these compounds gives abnormal flavour to milk. Normal milk has smooth feeling in mouth.

A notable compound methyl sulphide present in p.p.b (parts per billion) level up to 12 p.p.b in water gives flavour similar to that of milk. This compound is present in milk and cow's breath and significantly contributes towards the flavours of milk.

Off-flavours are referred to the flavours, which are not typical of the food such as milk and are considered undesirable. These undesirable flavours are often off shoot from undesirable compounds generated generally as post contamination.

Milk is particularly susceptible to off-flavours. These generally start from the milking animal such as cow or buffalo and include feed and fodder, weeds and barn contamination. These factors may create problem for flavour of milk**.** Contaminations such as bacteria, metals etc., also contribute towards off-flavours. Problems of off-flavours can be eliminated or avoided by carefully considering the above factors.

ii. Chemical flavour deteriorations

a) **Oxidized flavour:** Oxidized flavour is one of the most important aspect of flavour deterioration of milk and milk products. It is perhaps one of the single most important factor of off-flavour of milk. Oxidized flavour is a general term and include off-flavours such as cardboard, metallic**,** oily and tallow.

Cause of off-flavour of milk: The component responsible for off-flavour is the fat or lipid part of milk which undergo oxidation and generates off-flavours. Phospholipids of milk serve as the origin of oxidized flavour of milk. During milk fat separation one third of the phospholipids are found in skim milk. Sweet cream buttermilk is highly susceptible to off-flavour due to high content of phospholipids in butter milk.

Mechanism of oxidized flavour development in milk: Oxidized flavour is

produced from hightly unsaturated fatty acids such as linoleic acid present in phospholipids. Oxygen from the air attacks the methylene group adjacent to the double bond present in these acids, resulting in the formation of peroxides, hydroperoxide and breakdown products such as various aldehydes and ketones. One compound 2-octenal and 2-nonenal has the most characteristic oxidized property.

b) **Rancid Flavour (hydrolytic rancidity):** Hydrolytic rancidity is caused by natural milk enzyme lipase present is milk. Lipase releases free fatty acids from glycerides of milk fat. One of the most notable fatty acid butyric acid when released causes rancid flavour

Glyceride D Glycerol +Butyric acid

Lipase is inactive in the freshly drawn milk because it is present in the serum phase of milk. However, during handling of milk lipase is absorbed on the fat which can cause lipolysis and produce rancid flavour. Amongst the factors which cause and enhance rancidity are homogenization, vigorous agitation, warming and cooling of milk.

Prevention of Lipolysis: Problems of lipolysis is the release of lower chain fatty acids of milk fat such as butyric acid which renders it unacceptable for human consumption.

Lipolysis can be reduced or avoided by inactivating lipase. For this the following parameters should be considered:

1. Pasteurization of milk destroys lipase in milk
2. Avoid excessive agitation which should not be prolonged for a long period especially accompanied by foaming
3. Homogenization of milk
4. Separation or clarification.
5. Warming milk to 80-90^{0}C and cooling again to low temperature
6. Secretion of milk during advanced stage of lactation
7. Freezing and thawing of milk
8. Mixing of raw milk with cream or homogenized milk should be avoided.

c) **Sunlight Flavour:** When milk is exposed to direct sunlight it leads to the development of sunlight flavour which is undesirable. Sunlight off-flavour is caused due to two-reasons which are -

- Development of oxidized flavour as a result of light exposure.
- Sunlight flavour as such which is sometime refered as burnt flavour.

Methional is the sunlight off flavour compound produced due to direct exposure of sunlight. It gives off-flavour to as low as 1 part in 20 million. It is formed due to the reaction of **methionine** released from hydrolysis of protein in the presence of **riboflavin.**

Methionine + Riboflavin D Methional

Prevention: Avoid exposure of milk to direct sunlight or artificial light.

iii. Heated Flavours

Milk is always subjected to heating to preserve the same. Heat is required in the preparation of milk products. Heating process involve pasteurization, forewarming, boiling, superheating and sterilization of milk.

Pasteurization: Pasteurization whether holder or short-time process has hardly any effect on the development of flavour in milk. However, pasteurization is now an acceptable process for milk preservation without any change in flavour

Pre-heating/Forewarning: At or above 74^0C distinct flavour changes occur in milk. Notable amongst is the development of cooked flavour caused by the formation of H_2S. Hydrogen Sulfide (H_2S) is formed by the amino-acid methionine with a lowering of oxidation-reduction potential of milk.

Superheating: When heating is carried out for 75^0C for long period cooked flavour is changed to caramelized flavour. Chemical nature of caramelized flavour is not known. Since caramelized flavour is absent in whey it appears that casein plays an important part in caramelization.

Browning: However, caramelizing is accompanied by browning reaction. The reaction is known as Stecker degradation. This reaction occurs between the amino group of a basic amino acid such as lysine with free aldehyde group of sugar resulting in browning.

iv. Other off - flavours

Coconut Flavour: Coconut flavour originates from milk fat. Recent research shows that a compound delta lactone is formed from milk fat. It is a storage related defect and is favoured at high storage temperature rather than cooling.

Microbial flavour: Milk is a favourable medium for the growth of microbes particularly bacteria. These microbial changes are also accompanied by chemical changes. Such types of flavour changes are encountered with defects including bitter, fruity, rancid, stale and putrid-type of off-flavours.

Absorbed flavour: Absorbed flavours are those, which are other than those off-flavour caused by microbial or chemical action. These off-flavours are accidentaly absorbed in milk from several sources. These flavours can absorb either before or after milking. These flavours can enter through milking animals by the nose or mouth, to the lungs, to the blood stream, to the udder cells, and into the milk. Feeds and fodders fed to the animal are the main cause of absorbed flavours. Thus if a cow eats onion or garlic the flavour is transfered to the milk within 20 to 30 minutes. Milk can also absorb flavour from the atmosphere, improperly clean utensils and equipments. Residual disinfectant or any other odorous substance sticking to the metal surface has the potential to cause off-flavour in milk.

Check Your Progress 4

1. What are three basic sensory aspects of flavour of milk?

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2. Why flavour is important to a consumer?

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3. Name the components linked with natural flavour of milk.

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4. Name the notable compound responsible for flavour of milk.

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5. Explain off- flavour.

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6. Name the major off-flavours of milk.

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7. Name the compound responsible for oxidized flavour of milk.

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8. State hydrolytic rancidity and its control.

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8.6 NUTRITIVE VALUE OF MIL AND MILK PRODUCTS

Newly born infant is unable to ingest and assimilate nutrients from any food source other than milk. Consequently, milk has to provide all the growth, in an easily acceptable form. The nutrients present in milk and milk products are present in the form of carbohydrates, proteins, enzymes, minerals, vitamins, etc., which provide these nutrients in an easy and palatable manner. They not only provide a nutritious diet but also give energy and meet the day to day nutritional needs.

Role of constituents of milk and milk products

- Growth
- Supply of energy
- Maintenance of body
- Recovery from disease
- Reproduction
- Provide taste and appetite and palatability.

Milk and milk products in the form of food not only meet the nutritional requirement but also supplement the above requirements. Apart from birth of the infant these requirements are fulfilled by milk and milk products from growth phase to adult stage. Composition and nutritive value of milk and milk products are given in Table 8.13.

Table 8.13: Nutritive components in milk and milk products (100 g)

Product	Calories	Water g	Protein g	Fat g	Ash g	Carbo-hydrate g	Calcium mg	Phosphorus mg	Iron mg
Whole milk (cow)	68	87.0	3.5	3.9	0.7	4.9	118	93	0.1
Skim milk	36	90.5	3.5	0.4	0.8	5.1	123	97	0.1
Evaporated milk	138	73.7	7.0	7.9	1.5	9.9	243	195	0.2
Condensed milk	320	27.0	8.1	8.4	1.7	54.8	273	228	0.2
Skim milk (dry)	362	3.5	35.6	1.0	7.9	52.0	1300	1030	0.6
Butter	716	15.5	0.6	31.0	2.5	0.4	20	16	0
Butter milk	36	90.5	3.5	0.1	0.8	5.1	118	93	0.1
Cheddar cheese processed	370	40	23.2	29.9	4.9	2.0	673	787	0.9
Cottage cheese	95	76.5	19.5	0.5	1.5	2.0	96	189	0.3
Cream	204	72.5	2.9	20.0	0.6	4.0	97	77	0.1
Ice cream	207	62.1	4.0	12.5	0.8	20.6	123	9	0.1
Dried whey	344	6.2	12.5	1.2	7.7	72.4	679	576	-

Product	Sodium mg	Potassium mg	Vitamin A mg	Vitamin B1 mg	Vitamin B2 mg	Nicotinic acid mg	Vitamin C mg	Niacin mg
Whole milk (cow)	50	140	160	0.04	0.17	0.1	1.0	0.1
Skim milk (cow)	52	150	Traces	0.04	0.18	0.1	1.0	0.1
Evaporated milk	100	270	400	0.05	0.36	0.2	1.0	0.2
Condensed milk	-	-	430	0.05	0.39	-	1.0	0.2
Skim milk (dry)	77	1130	40	0.35	1.96	1.1	7.0	1.1
Butter	980	23	2300	Traces	0.01	0.1	0	0.1
Butter milk	130	140	Traces	0.04	0.18	0.1	1.0	-
Cheddar cheese	700	92	1400	0.02	0.42	Traces	0	Traces
Cheddar cheese processed	1500	80	1300	0.02	0.41	Traces	0	-
Cottage cheese	290	72	20	0.02	0.31	0.1	0	-
Cream	-	-	830	0.03	0.14	0.1	1	-
Ice cream	100	90	520	0.04	0.19	0.1	1	0.1
Whey dried	-	-	50	0.49	2.5	0.8	-	-

Source: Principle of Dairy Chemistry, R. Jenness and S. Patton (1959)

Products like condensed and evaporated milk are also easily digestible which flocculates the protein during heating thus improving digestibility. Likewise, fermented milk products such as dahi, yoghurt, lassi etc., have high therapeutic value because of microbial population which degrade milk components including protein. They also enhance the digestibility of these products.

i. Fat

Lipids are one of the most important constituents of milk. They have an important bearing on the economics of milk and milk products although this picture has changed somewhat due to the importance being ascribed to solids-not-fat also. Nutritive value of milk fat is due to its high calorie value of 9 kilocalories per gram. Second, it serves as a carrier of the fat soluble vitamins A,D,E and K. Milk fat also contains significant amounts of so called essential fatty acids (linoleic and arachidonic acids).

Major role of milk fat in milk and milk products is that it is linked with their flavour. There are no other fats, which can replace this role. The rich and pleasant flavour of milk fat cannot be duplicated. Milk fat in the form of butter, ghee, ice cream, coffee and whipping cream has its own flavour, taste and nutritive value.

The main function of milk fat is to supply energy. However, excessive intake of milk fat often leads to obesity, which leads to deposition of fat in the adipose tissue of the body. Thus there is a trend to consume milk and milk products with low fat. During starvation the body fat is utilised for energy.

Like essential amino acids of proteins there is a body requirement and need for essential fatty acids which cannot be synthesized as such. These are three unsaturated fatty acids, namely, linoleic, linolinic and arachidonic acids, Nearly 99 percent of the milk fat is present as triglycerides of fatty acids. Major portion of these triglycerides is lower chain fatty acids. They are responsible for the pleasant aroma, flavour and taste of milk fat. Amongst these fatty acids butyric acid is the major saturated fatty acid. Emulsifying properties of milk fat are related to phospholipids which are present to the extent of 1 per cent of total milk fat. A discouraging factor for milk fat is the presence of cholesterol in milk fat which accounts for 0.40 percent of total milk fat. Cholesterol is implicated in heart disease called artheroschlerosis and its awareness has led to lower milk fat consumption. However, milk fat remains the costliest constituent of milk because of its additional secondary role by imparting flavour to milk and milk products. Milk fat enhances their palatability and acceptability leading to enhanced consumption of milk and milk products

ii. Milk Protein

Milk contains proteins in the form of casein and whey proteins. The amino acids of these proteins are released during digestion in the stomach. These serves as structural building blocks of other body proteins. Our body is able to synthesize some amino acids but others have to be supplied by foods. Twenty amino acids are required by our body for growth and synethesis of proteins. Of the twenty amino acid 10 are not synthesized by our body. They are known as essential amino acids. They have to be supplied through diet. Milk is a rich source of essential amino acids, which comprises tryptophan, phenylalanine, lysine, threonine, valine, methionine, leucine, arginine and histidine.

Whey proteins have very high nutritional value for youngsters, adults and geriatric people, which acts as a tonic for body health maintenance. Whey protein concentrates are used as supplements in the preparation of high protein foods, low fat foods, low salt food etc. Low lactose intolrence food, geriatric food formulation for old age person with low digestibility, pregnant, lactating and nursing women foods for children

(Pediatric foods) for growth, anaemia and memory boosting foods are now available. For general vitality sickness or convalescence when most other form of foods are unacceptable dairy products provide the required nutrition.

Whey protein concentrate have been used as biopreservative and antioxidants. They are also used as functional foods due to their high emulsification, gelation, whipping etc., properties. Whey protein concentrate differs somewhat due to processing variables, pretreatment given to whey during handling and manufacture.

Biological value (B.V) of cow's milk is 90, which is an index of nutritive value of milk proteins. Biological value of milk proteins increases when it is mixed with cereals. Biological value refers to the quality of protein or nitrogen protein that may have participated in tissue construction or the percentage of nitrogen absorbed that is made use of by the body.

B.V of egg protein is 96, goat meat 76 and raw soyabean 57. Milk proteins have high buffering effect on stomach and is a remedy for excessive stomach acidity. Milk and milk products are, therefore, used in the dietary therapy for person suffering from acidity and gastritis. Milk proteins readily blend with other proteins or foods and provide supplementary dietic foods. On the negative side milk proteins have allergic property, which can be avoided by taking other proteins.

Nutritive value of products like cottage cheese, channa, rasogolla etc., is largely due to its curd, which is easily digestible. The curd is also a concentrate of casein which is a source of high quality protein.

iii. Carbohydrate

The main carbohydrate of milk is lactose, which is present at a concentration of about 5 percent. Carbohydrate provides energy at the rate of 4.0 kilocalories per gram. Lactose plays an important role as a source of energy. It has other nutritional functions as a sugar enhancing taste of milk and as a sweetener enhancing palatability.

Lactose performs several functions in the body. During intake of lactose through milk it takes a longer time for ingestion than the common carbohydrate cane sugar or sucrose. The increased ingestion time in the stomach favours the growth of desirable bacteria, namely, lactobacillus species preventing undesirable organisms damaging putrefactive in the gastro intestinal tract. Lactose helps in the absorption of calcium by its chelating action. This action of lactose is through the absorption of calcium as calcium lactate. Lactose intolerance is one undesirable property of lactose in some individuals. During the ingestion of lactose in small intestine it is broken down to glucose and galactose by the enzyme lactase, also called -glycosidase. The enzyme may be destroyed during illness or genetic disorders. This may result in non-breakdown of lactose to its monosaccharides units i.e. glucose and galactose. This defect is known as lactose intolerance. This intolerance can be overcome by either avoiding taking milk or consuming hydrolytic milk products such as dahi, yoghurt, lassi etc.

iv. Vitamins

Milk and its products contain both water soluble and fat-soluble vitamin. Their role is summarized as follow:

1. **Vitamin A:** Retina of eyes, mucous membrane infection prevention, night blindness, maintenance of good health
2. **Aneurin, thiamine (vitamin B_1) :** Anti beri-beri, polyneuritis, body maintenance
3. **Riboflavin (vitamin B_2):** Oxidation-reduction changes in milk
4. **Nicotinic acid:** Skin disorder e.g. Pellagra disease

5. **Pyridoxine:** Anti pellagra factor
6. **Biotin:** Promotes skin development
7. **Folic acid:** Prevent pernicious anaemia
8. **Vitamin C:** Prevent scurvy
9. **Vitamin D:** Prevention of rickets (bone disease)
10. **Vitamin E:** Anti sterility

A summary of the distribution of vitamin in milk and dairy products is given in the Table 8.14.

Table 8.14: Distribution of vitamin in milk and milk products.

Milk and milk products	A	B1	B2	C	D
Raw whole milk	Fair good	Very fair	Good	Very fair	Very fair
Pasteurized milk	Good	Slight	Good	Slight	Very fair
Sterilized milk	Good	Very	Good	Very slight	Very fair
Dried whole milk	Good	Slight	Good	Slight	Fair
Evaporated whole milk	Good	Very slight	Good	Very slight	Fair
Condensed whole milk sweetened	Good	Slight	Good	Slight	Fair
Separated milk Butter milk	Absent	Very fair	Good	Very fair	Absent
Cream	Good	Slight	Slight	Slight	Fair
Butter	Good	—	—	—	Fair
Cheese	Good	Slight	Very fair	—	Fair

Source: Dairy Chemistry and Animal Nutrition, M.M. Rai (1964)

v. Minerals

Milk and milk products are a good source of minerals, especially calcium and phosphorus. Our body requires various minerals such as calcium, phosphorus, magnesium, sulphur, nitrogen, sodium, potassium and chlorine (as chloride). There are certain trace elements, which too are needed by individuals in traces. These include iron, copper, zinc, cobalt and iodine.

Milk contains calcium and phosphorus in the ratio of 1.3:1 required for optimum growth. This ideal ratio meets the need of a growing child and different individuals with varying age groups.

Trace elements are required by our body in traces. They are needed in ppm or in small quantity. Their nutrition role is as important as of major elements. For example iron is an integral part for the formation of blood protein haemoglobin needed to prevent anaemia. Likewise Cobalt is required for vitamin B_{12} molecule which contains cobalt in its structure. Hormone thyroxine secreted by thyroid gland is secreted as thyroxine. Iodine deficiency leads to enlargement of thyroid gland.

Except for iron, milk is a good source for trace elements especially zinc, nickel, molybdenum which are considered important for nutrition and proper functioning of certain specific enzyme activities. Milk is an excellent source for calcium and phosphorus. Calcium is an integral part of bones and teeth. Along with phosphorus they are involved in the formation of teeth and bones. Milk meets the entire need of these minerals.

Finally it may be concluded that milk is good source of all the minerals except iron and iodine.

Check Your Progress 5

1. Explain why milk is essential for infant.

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2. State caloric energy of lipids.

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3. Name the fat-soluble vitamins.

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4. Name the mineral for which milk is an excellent source.

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8.7 LET US SUM UP

Food is required for growth, reproduction, supply of energy, maintenance and recovery from diseases at different stages of life. These functions are met by milk and milk products. Milk and milk products meets the nutritious needs of infants, adults, old and convalescence. The functions of milk are served through its constituents including protein, fat, lactose, vitamins, and minerals. Milk contains 20 amino acids. Milk is a source of high quality proteins, which have a high biological value of 90. Milk is a rich source of calcium.

Unravelling the composition of milk and its constituents has been a challenging problem due to the complex nature of milk. A knowledge of the composition of milk, its constituents and factors affecting the composition of milk lead to the understanding of the physico-chemical nature of this complex biomolecule. The average gross composition of milk varies due to several factors, which affect the composition of milk. There are several factors including species, breed, stage of lactation, feeding etc.

Flavour and off-flavour are important from the point of view of consumer and food acceptance, and palatability. Flavour is affected by heating, contamination and various other factors. There are several components, which are responsible for flavour and off-flavour.

Milk and milk products play an important role in nutrition. This has resulted in the preparation of several food products especially whey protein concentrate.

8.8 KEY WORDS

SNF	:	Solids-not-fat
Kilocalorie	:	A unit of heat energy
Nutrional	:	Needed for nutrition
Triglyceride	:	Constituent of fat made up of glycerides of fatty acids
Fortify	:	To add or enhance a nutritive quality of food.
Essential amino acid	:	Amino acids which can not be synthesised by body.
Lactose	:	A disaccharide sugar of milk
Hydrolysis	:	Chemical break down of complex compounds into simple one.

8.9 SOME USEFUL BOOKS

Jenness R and Patton S. (1959) Principles of Dairy Chemistry, John Wiley's, USA.

Ling E.R. (1956) A text Book of Dairy Chemistry Vol 1 & 2, Chapman and Hall, London.

Webb B.H. and Johnson, A.H (1979) Fundamentals of Dairy Chemistry, AVI Publishing Co, Connecticut, USA

Rai, M.M.(1964) Dairy Chemistry and Animal Nutrition, Kalyani Publishers, New Delhi.

Mathur M.P. Datta Roy, D, and Dinakar (1999) Test Book of Dairy Chemistry I.C.A.R. New Delhi.

8.10 ANSWER TO CHECK YOUR PROGRESS

Your answers should include following points.

Check your Progress 1

1) i. The composition of cow and buffalo milk is as follow (As percent)

		Water	TS	Fat	Lactose	Protein	Minerals	SNF (Minimum)
1.	Cow	87.2	12.8	4.0	4.7	3.4	0.7	8.8
2.	Buffalo	83.5	16.5	7.2	4.8	3.8	0.7	9.3

2) i. Lactose is the highest constituent of human milk with a level of 6.8%

3) i. Level of protein in sheep milk is 4.5 %

Check Your Progress 2

1) i. The three different states in which milk constituents are present are:
   a) Fat is present as an emulsion
   b) Protein along with a portion of mineral matter is present in colloidal state
   c) Remainder of mineral matter and lactose and present in true solution
2) i. The range of size of casein micelles is between 30-300 millimicron
3) i. Casein coagulates at pH 4.6.
4) i. The molecular weight of beta lactoglobulin is 36,000 dalton
5) i. Immunoglobulin
6) i. True

Check Your Progress 3

1) i. Human milk has lowest percent of protein, which is 1.30 percent
2) i. Colostrum is different from normal milk because of its high concentration of globulin protein, namely, immunogobulin which is present in very high concentration in colostrum.
3) i. With advancement in age there is a slight decrease in fat content. An irregular decline in S.N.F. also occur. Within S.N.F casein and lactose are the main components which are mainly affected

Check Your Progress 4

1) i. The three basic sensory aspects of flavour in milk are
   - olfactory
   - gustatory
   - tactual
2) i. Flavour is important to the consumer because if the flavour is poor milk will be rejected inspite of the fact that the food is wholesome, nutritious or reasonably priced.
3) i. Components linked with flavour of milk are acetone, acetaldehyde, butyric and certain other free fatty acids. Methyl sulphide also contributes towards the flavour of milk.
4) i. Notable component is melthyl sulphide upto 12 p.p.b
5) i. Off - flavour are referred to the flavours which are not typical to the food such as milk and are considered undesirable.
6) i. Major off- flavours of milk are oxidized, lipolytic or rancid, sunlight, heated, coconut and absorbed flavour.
7) i. Compound responsbile for oxidized flavour is 2-octenal and 2- nonenal.
8) i. Hydrolytic rancidity is the rancidy caused by lipase through the release of butyric acid. It can be prevented by pasteurization, avoiding excessive agitation of milk, homogenization, warming to 80-90^{0}C, freezing and thawing, mixing of raw milk with cream.

Check Your Progress 5

1) i. Milk is essential for infants as they are unable to digest any other food other than milk which is readily digestible and meets its nutrition requirement
2) i. Lipids gives 9 kilocalorie energy/g
3) i. The fat soluble vitamins are vitamin A,D,E & K
4) i. Calcium is the mineral for which milk is an excellent source

Check Your Progress 6

1) i. Living being requires food for various purposes. These include food for growth, reproduction, and supply of energy, maintenance and recovery from diseases at different stages of life. These functions are met from foods from different sources. Milk is an extremely useful food, which contributes towards nutrition of human being.

2) i. The main constituents of milk which perform nutritional functions are lactose, milk proteins, lipids or fat, enzymes, minerals, and vitamins.

3) i. Twenty essential amino-acids are required by our body of which 10 are essential amino acid.

4) i. Lactose is retained for a longer period in our body because of its greater resistance towards microbial fermentation.