UNIT 1
Food Product Technology

Objectives

- To know the chemical composition of milk.
- To understand processing of milk and various milk products.
- To understand need and importance of livestock, egg, fish and poultry.
- To study structure, composition and nutritional quality of animal products.

The food products are generally obtained from two major sources: animal kingdom and plant kingdom by the use of technology.

Milk is considered a complete food from the times of our ancestors. It is a widely consumed beverage that is essential to the diet because it provides complete food nutrient including important macro- and micro-nutrients. Owing to its high perishable nature, it is required to process into various value added products having high nutritional value with longer shelf life.

Man has been using meat, fish, poultry and eggs in his diet since time immemorial. Meat is an animal flesh that is eaten as food. Meat and meat products can provide an important nutritional contribution to the human diet. They are rich and concentrated sources of nutrients including fats, proteins, vitamins and minerals, etc. Eggs are one of the few foods that are classified as "superfoods." They are loaded with nutrients, some of which are rare in the modern diet. Poultry are domesticated birds raised for food. Fish is a high-protein, low-fat food that provides a range of health benefits.

Beverage is any liquid consumed by humans for quenching their thirst, meeting food requirements or merely for pleasure.

1 Milk and Milk Products

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1.1 Composition of milk

1.2 Effect of heat, acid and enzymes on milk

1.3 Processing of milk

1.4 Milk products

Milk is the biological liquid secreted by mammary gland of mammals. All mammals, including humans, normally produce milk to feed their offspring until they are ready for consuming solid food. Cow is the principal sources of milk for human consumption in many parts of the world. Other important sources of animal milk are buffalo, goat, sheep, camel etc. India is the largest producer of milk.

Milk contains valuable nutrients and offers a range of health benefits. It is regarded as a complete food because of its rich source of nutrients such as protein, fat, carbohydrates, vitamins and minerals, essential for sustaining life and maintaining good health.

Do you know ?

Milk is good for bones because it offers a rich source of calcium which is essential mineral for healthy bones and teeth. Cow's milk is fortified with vitamin D, which also benefits bone health. Calcium and vitamin D helps to prevent osteoporosis. That is how milk is considered as 'complete food'.

Do you know ?

World Milk Day (1st June) is an international day established by the Food and Agriculture Organization (FAO) of the United Nations to recognize the importance of milk as global food.

Dr. Verghese Kurien, (26 November 1921 to 9 September 2012) known as the 'Father of the White Revolution' in India. He made dairy industry as India's largest self-sustaining dairy industry by using village cooperative movement in Anand, Gujarat. He helped to create rural co-operative model not only for India, but for developing countries throughout the world.

1.1 COMPOSITION OF MILK:

Milk is a complex fluid which contains more than hundred components. Most of these components are suspended in water and thus milk is a colloidal solution and has opaque consistency. The major components of milk are water, protein, fat, carbohydrates, vitamins and minerals. All the solids in milk are referred to as 'total solids' and the total solids without fat are known as milk solids-not-fat (SNF). The composition of milk varies with the species, breed, feed, lactation period and interval between milking. The average nutritional composition of milk of animals and human beings is given in table 1.1.

1.1.1 Water:

Milk contains 81-88 percent water, hence it is in a liquid state. All the constituents are dispersed in water phase which help in their digestion.

1.1.2 Protein:

All milk contain approximately 3-4 percent of protein. The main protein in milk is casein, which accounts for about 80 percent of the total milk protein present. It is a phosphoprotein. The normal pH of milk is 6.6 at which casein is combined with calcium and present in the form of calcium caseinate. The remaining 20 percent proteins of milk are the whey proteins which contain lactalbumin and lactoglobulin.

1.1.3 Fat:

The fat content of milk varies from 3.5 percent in cow's milk to about 6.5 percent in buffalo's milk. The flavour of the milk is due to milk fat. Milk is an oil-in-water emulsion. Fat globules are visible under a microscope. Milk fat absorbs volatile odours readily. Milk contains saturated and unsaturated fatty acids. Yellow colour of cow's milk fat is due to carotene (precursor of vitamin A) content. The price of different types of dairy milk varies according to the fat content. The higher the fat content, the higher is the price of that milk.

1.1.4 Carbohydrates:

Milk contains about 4 to 5 percent carbohydrates. The chief carbohydrate of milk is lactose sugar; a disaccharide composed of two monosaccharide units, i.e. glucose and galactose. Milk is the only source of lactose and no other food contains it, hence lactose is called as milk sugar which gives sweet taste to milk. When milk is heated lactose reacts with protein and develops a brown colour.

Do you know ?

Galactose is called as a brain sugar

Do you know ?

Lactose intolerance is a disorder in which a person lacks the enzyme lactase, which is capable to break down the lactose sugar. People with lactose intolerance are unable to digest the milk sugar as they do not have the enzyme lactose in their digestive system. Soy milk, coconut milk are dairy alternatives for people suffering from lactose intolerance. Animal milk is considered as 'bovine milk', while the milk from seed coconut, soya, almond are referred as vegan milk.

1.1.5 Minerals:

The important minerals present in milk are calcium, phosphorus, sodium, potassium and iodine. The salts of these minerals function are as buffers maintaining the pH of milk at a constant level of about 6.5 to 6.6.

1.1.6 Vitamins:

Milk is a good source of both fat soluble and water soluble vitamins. Milk is especially rich in riboflavin but this vitamin is lost rapidly on exposure to light and may produce an oxidized off flavor. The concentration of niacin and ascorbic acid is relatively low in milk. Some milk do not contain a sufficient amount of vitamin D and this is added in fortified milk to make it enrich with vitamin D.

Table 1.1 Nutritional composition of milk from various sources (per 100 ml)

Composition	Cow	Buffalo	Goat	Human
Water (ml)	87.5	81.0	86.8	88.0
Protein (g)	3.2	4.3	3.3	1.1
Fat (g)	4.1	6.5	4.5	3.4
Carbohydrate (g)	4.4	5.0	4.6	7.4
Energy (Kcal)	67	117	72	65
Calcium (mg)	120	210	170	28
Phosphorus (mg)	90	130	120	11
Carotene (µg)	53	48	55	41
Riboflavin (mg)	0.19	0.10	0.04	0.02

Source: Nutritive value of Indian Foods, National Institute of Nutrition, Hyderabad

Do you know ?

The National Dairy Research Institute (NDRI), Karnal is India's premier institute for dairy research.

1.2 EFFECT OF HEAT, ACID AND ENZYME ON MILK:

1.2.1 Effect of heat:

Heating of milk is done to kill the pathogenic microorganisms and enzymes present in it. The extent of changes depends on the temperature and period of heating. The changes affect the colour, flavor, taste and viscosity of milk. A light brown tinge is developed on prolonged heating of milk. The heat labile whey proteins undergo denaturation and coagulation. Generally, there is scum formation when milk is heated in an uncovered pan or vessel. The scum gets thickened as the temperature is increased e.g. *basundi.*

Milk boils at about 100.2^{0}C. When milk is heated in open vessel, a scum (*malai*) is formed on the top of the milk. This is because of evaporation of water and concentration of casein, which blocks calcium salt and milk fats. Heat also has an adverse effect on the flavour and odour of milk. The 'cooked' flavour of boiled milk is attributed to the loss of dissolved gases (CO_2 and O_2).

1.2.2 Effect of acid:

In milk, casein is present at pH 6.6 as calcium caseinate. When the acidity of milk increases either by the addition of acid or by natural souring, casein is precipitated e.g. curdling. At higher temperature the addition of acid hastens the coagulation of milk proteins. Increase in acidity also hastens coagulation of milk proteins. A very good example of this phenomenon is the preparation of *paneer*, which is prepared by adding lemon juice/citric acid to hot milk, leads to separation of solids (proteins) and liquids (whey).

1.2.3 Effect of enzyme:

Rennin, an enzyme secreted in the young calves intestine, after adding to milk, brings about the coagulation of milk protein. Due to addition of rennin, casein gel is formed. Coagulation of milk by rennin depends on temperature, pH, salt and heating of milk before enzyme action. The

enzyme bromelin from pineapple also clots the milk.

1.3 PROCESSING OF MILK:

Milk is processed by heating, concentrating, evaporating, drying, etc. It helps to produce milk that has low bacterial count, good flavour with satisfactory keeping quality and adds variety to our meals. In general the milk processing operations are as follows:

1.3.1 Pasteurization:

Pasteurization is a process which consists of heating milk to certain temperature for a definite time to ensure destruction of pathogenic bacteria and enzymes. At present, pasteurization is considered as an essential feature in the manufacturing of processed milk and milk products such as butter, ice cream, cheese, etc. Pasteurization of milk destroys about 99 percent of all bacteria, yeasts and moulds. It also inactivates some of the natural enzymes like lipase and improves the keeping quality of milk.

There are three methods used to pasteurize milk:

1. **Holding Method (Batch type):** Milk is heated to 62.8^{0}C temperature and holding it for 30 minutes.

2. **High Temperature Short Time method (HTST):** Milk is heated to 71.7^{0}C temperature for 15 seconds. This method does not impart cooked flavor.

3. **Ultra High Temperature Method (UHT):** Milk is heated to 137.8^{0}C temperature or more for 1 to 2 seconds. This method does not impart cooked flavor. This helps in storing milk for long period, retaining its palatability and protecting it from getting spoil.

1.3.2 Homogenization:

Homogenization, a the process of breaking down fat globules into tiny particles in milk so that they stay integrated rather than separating as cream. This is achieved by passing warm milk or cream through a small aperture under high pressure and velocity. Milk fat globules are formed to 1 to 20 micron in diameter. It decreases the size of fat globules and increase their number with surface area. Homogenized milk has a creamier thick consistency, bland flavour and whiter appearance.

In the manufacturing of ice-cream, homogenization reduces the chances of separation of fat globules resulting in a smoother texture of the finished product as shown in fig. 1.1.

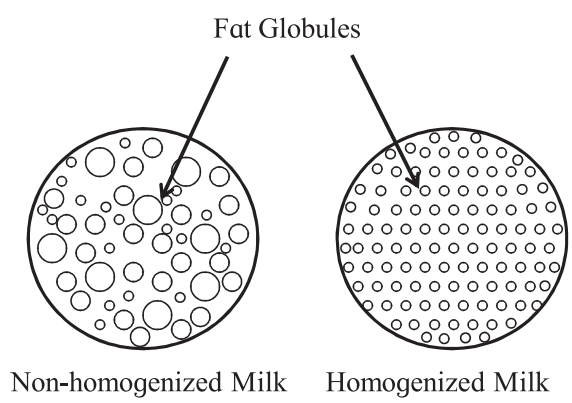

Fig. 1.1 Fat globules in milk

1.3.3 Sterilization:

Milk is heated to a high temperature of 148.8^{0}C and held for 2 to 3 seconds. It assures complete destruction of micro-organisms (bacteria, yeast and mould). The milk is then aseptically packaged, usually in tin cans or tetra packs. Sterile milk is very useful for extended shelf life where refrigeration is not available.

1.3.4 Concentration:

Condensed milk is one which has been concentrated from full cream milk by removal of its water with or without addition of sugar. The removal of water is achieved at a relatively lower temperature by bringing down the boilling point to 55^0C to 63^0C by reducing pressure.

1.3.5 Skim milk (Vacuum concentration process):

Skim milk is a milk from which fat has been removed. Fat content is reduced to 0.5 to 2 percent by centrifugation. Skim milk has lower energy value, higher protein, calcium and riboflavin content as compared to dried whole milk. Taste and flavour is reduced and fat soluble vitamins like vitamin A and D are also reduced. Skim milk is used for low calorie diets and for children who need high protein.

1.3.6 Drying:

Various milk products are made by removing different percentages of water from whole milk e.g. whole milk powder, skimmed milk powder, infant milk powder, butter milk powder, ice cream mix and malted milk powder. Milk powder can be reconstituted in fluid milk.

Drying of milk is done by two methods.

1. **Roller or drum drying:** Milk is sprayed on the surface of the heated metal cylinders in vacuum chamber under low temperature.
2. **Spray drying:** The milk is sprayed into a chamber of hot air by counter current flow. The moisture content of the finished dried dairy product is generally less than 4 percent which prevents the growth of microorganisms.

1.4 MILK PRODUCTS:

Children and adolescents should be encouraged to consume milk products due to their nutritive value. Milk product or dairy product covers a wide range of products which are given below:

1. Fresh milk, skimmed milk, toned milk, condensed milk, flavoured milk, etc.
2. Cream, butter, *khoa*, ghee, *channa*, *paneer*
3. Curd (*Dahi*), yogurt, *lassi*, buttermilk, *chakka*, *shrikhand*, cheese, etc
4. Ice-cream, *kulfi*, softy, etc.

Fig. 1.2 Milk products

5. Dried and condensed milk products: Milk powders (whole milk, skim milk), whiteners, etc.
6. Dairy byproducts- casein, caseinate, whey, whey concentrate, lactose, ghee residue, etc.

1.4.1 Curd (*Dahi*):

It is major product obtained from milk in India. In the preparation of curd, milk is boiled and cooled to 35^0 to 40^0C temperature and then little curd is added as starter culture from an earlier batch. The quantity of starter added depends upon the season of the year and severity of the climate. Various species of *lactobacillus*

and *streptococcus* micro-organism present in the starter curd (culture) multiply and convert lactose of milk to lactic acid which gives sour pleasant taste into the curd. Increased acidity results in casein coagulation. After 6 to 12 hours, depending on the climatic conditions, a smooth, firm, homogenous curd is formed. Curd is used in the preparation of *lassi*, *kadhi*, butter milk and salad dressings etc.

$$\text{Milk (liquid)} \xrightarrow[\text{warm temperature}]{\text{lactic acid bacteria}} \text{curd (gel)}$$

1.4.2 *Chakka:*

Curd is tied up in muslin cloth. All the water is allowed to drain out by hanging it for about 4 to 6 hours. The solid mass that remains in the muslin cloth is known as *chakka*. It is used for making *shrikhand* and allied products by adding sugar and fruit pieces

1.4.3 Cheese:

Cheese is made by coagulating milk with acid or rennin or both, drawing off the whey and processing the curd into a block. Desirable flavour and texture of cheese is obtained by a process called curing or ripening. It involves holding the curd at specific temperature and humidity for a specified period. Cheese is classified as hard, semi hard and soft cheese. Some important types of cheese are cheddar, swiss, gouda or dutch, cottage, mozzarella, camembert etc. It is used in preparation of sandwich, pizza and pastas.

1.4.4 *Paneer:*

This is obtained by acid coagulation of milk. Milk is coagulated by adding about 1 percent citric acid, lemon juice or vinegar to hot milk. Solid coagulum containing casein is formed and the liquid which separates out is called as whey. *Paneer* is obtained by pressing the coagulum and removing the whey. *Paneer* is also called as Indian cheese. It is used in preparations of variety of dishes such as paneer *paratha*, *paneer pulao*, *palak paneer* and sweets like *rasgulla*, *rasmalai*, etc.

Do you know ?

The curd bacteria, *lactobacillus* and *streptococcus* are considered as probiotic bacteria which are also known as gut bacteria helping in digestion of human beings.

1.4.5 Butter milk:

It is obtained by adding water to curd and churning it or as byproduct in the process of preparing butter. Buttermilk is used for the preparation of *kadhi* and *lassi*.

1.4.6 *Khoa:*

In India, surplus milk is used for preparation of *khoa*. In the preparation of *khoa*, milk is boiled in a small shallow, round-bottom iron pan stirring continuously in a circular motion with a scraper. During this process, proteins coagulate due to heat and evaporate sufficient moisture, on cooling, it solidifies. The yield is about 20 to 25 percent of the weight of the milk used. It is slightly brown in colour, has a sweet taste and pleasant odour. *Khoa* is used in preparation of various types of milk sweets like *pedha*, *sandesh*, *gulab jam*, carrot *halwa*, etc.

1.4.7 Cream:

Milk fat separated from milk by centrifugation is called as cream. Cream used for making butter usually contains 25 to 40 percent fat. Cream is also used in baked products, salad dressings, etc.

1.4.8 Butter:

Butter is an important dairy product in India. It is made from milk cream. The fat content of butter is generally 80 percent. The cream is pasteurized at 62.8^{0}C for about 30 minutes which is immediately cooled. Then a culture of desirable microorganisms (*lactobacillus* starter) is added. The cream is then allowed to ripen for several hours for fermentation. The ripened cream is next churned. The fat globules clump together, cream becomes granular and a definite separation of butter and butter milk takes place. The butter milk is drained off from the churner and butter is washed with water.

1.4.9 Milk powder:

It is prepared form either whole milk or skim milk. Milk can be dehydrated to obtain milk powder which contains moisture 3-4%. It can be stored up to six months or more by using appropriate packaging technology.

Table 1.2 Nutritive value of milk products (per 100 g)

Foods	Water (g)	Protein (g)	Fat (g)	Carbohydrates (g)	Energy (Kcal)	Calcium (mg)	Phosphorus (mg)	Beta-carotene (µg)	Riboflavin (mg)
Curd (Cow's milk)	89.1	3.1	4.0	3.0	60	149	93	102	0.16
Butter milk	97.5	0.8	1.1	0.5	15	30	30	-	-
Skimmed milk liquid	92.1	2.5	0.1	4.6	29	120	90	-	-
Paneer (bufflao's milk)	54.1	13.4	23.0	7.9	292	480	277	-	-
Cheese	40.3	24.1	25.1	6.3	348	790	520	273	-
Khoa (buffalo's milk)	30.6	40.6	31.2	20.5	421	650	420	-	-
Khoa (Skimmed buffalo milk)	46.1	22.3	1.6	25.7	206	990	650	-	-
Khoa (Whole cow's milk)	25.2	20.0	25.9	24.9	413	956	613	497	0.41
Skimmed milk powder (Cow's milk)	4.1	38.0	0.1	51.0	357	1370	1000	-	1.64
Whole milk powder (Cow's milk)	3.5	25.8	26.7	38.0	496	950	730	1400	1.36

Source: Nutritive value of Indian Foods, National Institute of Nutrition (ICMR), Hyderabad

Do you know ?

Why camel milk is a healthy dairy alternative?

Camel milk is considered as "White gold of the desert", due to its remarkable nutritional profile. National Research Center on Camel, Bikaner, Rajasthan is promoting camel milk and its value added products.

Points to remember

- Milk and milk products form an essential part of diet. They are excellent source of fat, protein, minerals (calcium, phosphorus) and vitamin (riboflavin).
- Effect of heat, acid and enzymes changes the physical and chemical properties of milk.
- Processing methods like homogenization, pasteurization, sterilization, dehydration help to increase the shelf life of milk.
- Various products like cheese, *paneer*, *khoa*, cream, *chakka*, curd, etc can be prepared from milk.

Exercise

Q. 1 a. Select the most appropriate option.

i. _____ is the whey protein.

a. Lactalbumin b. Rennin

c. Casein d. Gluten

ii. Sugar present in milk is _____

a. Sucrose b. Lactose

c. Maltose d. Fructose

iii. Keeping quality of milk is increased by _____

a. Pasteurization b. Homogenization

c. Skimming d. Churning

iv. Homogenization process reduces the size of _____ globules in milk.

a. Carbohydrate b. Lactose

c. Fat d. Proteins

v. Lactose of milk is converted in to lactic acid during _____ making process.

a. Curd b. *Khoa*

c. Cream d. Basundi

b. Match the following.

A		B	
i.	UHT	a.	71.7^{0}C
ii.	HTST	b.	62.8^{0}C
iii.	Sterilization	c.	137.8^{0}C
iv.	Holding method	d.	148.8^{0}C
		e.	100^{0}C

c. Do as directed.

i. State whether the following sentences are true or false.

a. Milk is water in oil emulsion.

b. The fat content of butter is generally 50 percent.

c. Camel milk is considered as yellow gold of dessert.

ii. Identify the odd word.

a. Butter b. Ghee

c. Milk Powder d. Meat

iii. Name the main carbohydrate present in milk.

L				O		

d. Unscramble the underlined word.

NACESI is the milk protein.

Q. 2 Short answer questions.

i. Define the following.

a. Homogenization

b. Skimming of milk

c. Pasteurization

ii. Write short notes on the following.

a. Drying

b. Denaturation and coagulation

c. Curd

iii. Answer the following

a. Enlist different milk products used in our diet.

b. Enlist various processing methods of milk.

Q. 3 Long answer questions.

i. Discuss in detail composition of milk.

ii. Explain the process of homogenization of milk.

Project:

i. Visit a dairy plant and prepare a report on the following:

a. Tests carried out on milk at processing plant.

b. Different process used on milk.

c. Milk product manufactured in the dairy unit

d. Packaging and storage of milk and milk products

ii. Visit a supermarket, collect information about various types of milk and milk products available and prepare a booklet on that information.

iii. Prepare charts on milk and milk products