CHAPTER

5

Milk and Milk Products

Milk is one food for which there seems to be no adequate substitute. All mammals produce milk after the birth of the youngones and man uses milk of many animals as his food. The cow is the most important of all these animals as supplier of food. Buffalo and goat milk is also used.

COMPOSITION

Milk is a complex mixture of lipids, carbohydrates, proteins and many other organic compounds and inorganic salts dissolved or dispersed in water. The most variable component of milk is fat followed by protein.

The composition of milk varies with the species, breed, diet, lactational period and interval between milking. There is individual variation also.

Milk fat

Buffalo's milk contains 6.5 per cent fat. Cow's milk contains 4.1 per cent fat. Milk fat or butter fat is of great economical and nutritive value. The flavour of milk is due to milk fat. Milk is a true emulsion of oil-in-water. The fat globules are stabilised by a surrounding membrane composed of proteins, phospholipids and cholesterol. Fat globules are visible under a microscope. Each globule of fat is surrounded by a thin layer which is composed of a lipid-protein complex and a small amount of carbohydrate. The lipid portion includes both phospholipids and triglycerides.

Fat globules vary widely in size from 2 to 10 μm (micro metres) and in number 3×10^9 per ml. The larger fat granules come to the surface of milk more quickly due to low specific gravity and this can be observed in the transportation of milk.

The structure of fat globule is shown in Figure 5-a.

Milk fat is a mixture of several different glycerides. They contain about 64 per cent fatty acids ranging from 4 to 26 carbon atoms. Milk contains considerable amount of short chain fatty acids which give the characteristic flavour and off flavour. Due to their low melting point –10 to 12°C, they give soft solid consistency to butter. Saturated fatty acids account for butyric and caproic acid 62 per cent and unsaturated 37 per cent. Of the unsaturated fatty acids, 3.8 per cent constitute polyunsaturated fatty acids. Other lipid materials present in milk are phospholipids, sterols, free fatty acids, carotenoids and fat-soluble vitamins. Carotenes are responsible for the yellow colour of milk fat. Gerber test is used to know the percentage of fat present in food.

Milk fat absorbs volatile odour very readily. Milk, butter and cream should not be exposed to strong odours.

Milk proteins

Casein: Casein constitutes 80 per cent of the total nitrogen in milk. It is precipitated on the acidification of milk to pH 4.6 at 20°C. The remaining whey protein constitutes lactoglobulin and lactalbumin. Milk protein contains proteoses, peptones and milk enzymes.

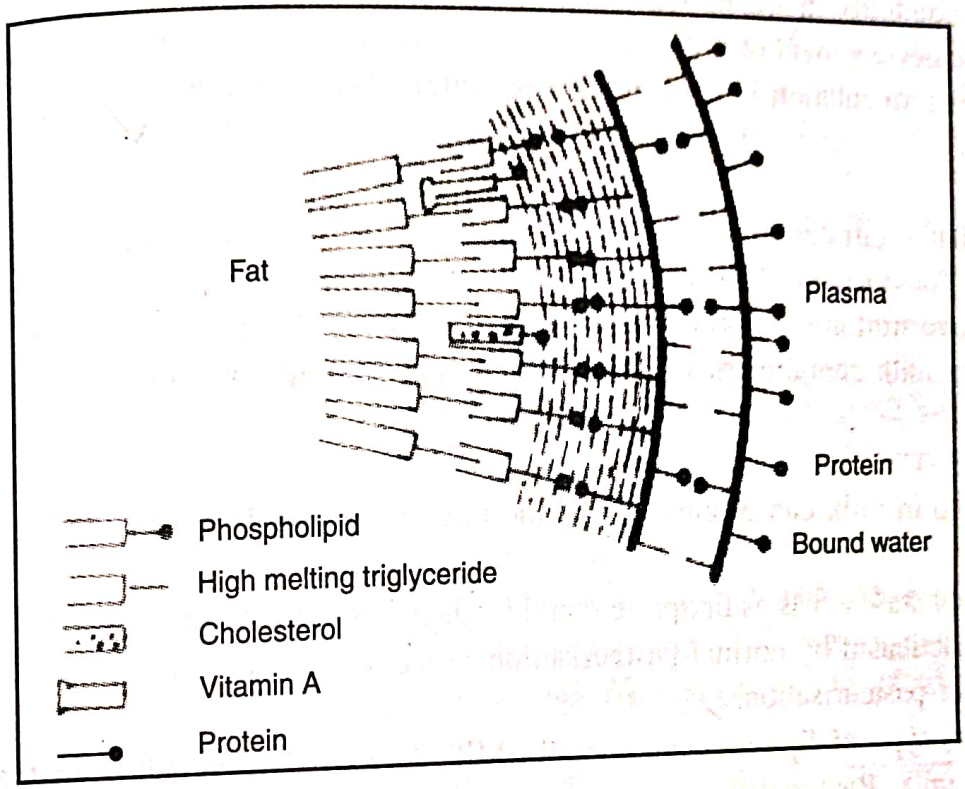

Figure 5-a: Structure of fat globule membrane in milk.

Source: Charley Helen, 1970, Food Science, John Wiley & Sons, New York.

Milk fat is composed mainly of triacylglycerols which are present as an emulsion in which the fat globules are stabilised by a surrounding membrane composed of proteins, phospholipids and cholesterol. The fat globules also contain small amounts of cholesteryl esters and fat-soluble vitamins and provitamins mainly A, D and β-carotene.

Casein is classified as a phosphoprotein because of the phosphoric acid that is contained in its molecular structure. At the normal acidity of fresh milk (about pH 6.6), casein is largely combined through the phosphoric acid part of its structure with calcium caseinate. Hence, casein occurs in milk as a colloidal protein calcium phosphate complex.

Casein is also a glycoprotein. Glutamic acid is the predominant one in casein. Proline, aspartic, leucine, lysine and valine are also present. Casein is a good source of essential amino acids. Casein contains 8.2 per cent calcium and 5.7 per cent carbohydrates.

Casein can also be separated from milk by the addition of rennin, an enzyme secreted by the young calves.

Whey proteins: Whey proteins are made up of α-lactabumin and β-lactoglobulin, serum albumin, the immunoglobulins, enzymes and proteose—peptones. β-lactoglobulin accounts for about 50 per cent of total whey proteins. These are not precipitated by acid or rennin, they can be coagulated by heat. Whey also contains small amounts of lactoferrin and serum transferrin. By a process involving

ultrafiltration, whey protein concentrate is produced. Whey protein isolates are also produced. It can be given in lactose intolerance.

Milk sugar

Milk contains 4-5 per cent carbohydrate. The chief carbohydrate present in milk is lactose, a disaccharide, although trace amounts of glucose, galactose and other sugars are also present. Lactose gives on hydrolysis glucose and galactose. Lactose has only one sixth the sweetness of sucrose and one third-one fourth of its solubility in water. When milk is heated, lactose reacts with protein and develops a brown colour. The development of brown colour is due to nonenzymatic browning. It is called *Maillard reaction*. The acid fermentation is used in making butter, cheese and curd.

Salts

Chlorides, phosphates, citrates, sulphates and bicarbonates of sodium, potassium, calcium and magnesium are present. These salts influence the condition and stability of the proteins, especially the casein fraction. Copper and iron are important in the development of off flavours in milk and milk products. In addition to this, milk contains trace elements like zinc, aluminium, molybdenum and iodine.

Enzymes

The enzymes found in milk can originate from the mammary glands or may be released by contaminating bacteria.

Alkaline phosphatase exists as lipoprotein and is distributed between the lipid and aqueous phases. This enzyme is inactivated by normal pasteurisation procedures and its activity is tested to determine the effectiveness of pasteurisation.

More than one type of lipase occur in milk. Milk lipase is responsible for the development of rancid flavours in milk. Bacterial lipase is very resistant to heat and can cause serious quality defects. Lipases may be important in the development of desirable flavours in some cheeses.

Xanthin oxidase occurs in the fat globule membrane. It is a conjugated protein complexed with FAD, iron and molybdenum. The enzyme degradation of FAD gives FMN and riboflavin. The riboflavin content of milk may thus be due to xanthin oxidase. Xanthine oxidase can catalyse the oxidation of aldehydes which are some of the aroma constituents in fermented dairy products. The enzyme is not destroyed by pasteurisation.

Colour

White colour of milk is caused by the reflection of light by the colloidally-dispersed casein, calcium and phosphorus. Yellowish colour of milk is due to the presence of carotene and riboflavin. Fat-soluble carotenes are found in milk fat; riboflavin is water soluble which can be visible clearly in whey water.

Flavour and aroma

Milk is slightly sweet because of its lactose content. Flavour sensation in mouth is due to fat protein and some of the salts such as calcium phosphate. The slight aroma of fresh milk is produced by a number of low molecular weight compounds such as acetone, acetaldehyde, dimethyl sulphide and short chain fatty acids. Some of the volatile compounds to the flavour of milk are unique to the fat portion of milk. Boiling changes the flavour of fresh milk more than pasteurisation.

Oxidised flavour can result from the oxidation of phospholipids in the milk. Since traces of copper accelerate the development of oxidised flavour, copper containing equipment is not used in dairies.

Some of the poly-unsaturated fatty acids are particularly susceptible to autooxidation in the presence of oxygen and unpleasant flavour substances are produced.

Off flavour in milk may be influenced by the health of the cow or the feeds that are consumed by the cow, action of bacteria, chemical changes in milk, or the absorption of foreign flavours after the milk is drawn.

Off flavours are also produced when milk is exposed to light. In this reaction, tryptophan and riboflavin may be involved and their content decreases when the off-flavour develops.

Anything that alters the membrane and permits contact of the lipases with the fat will promote rancidity and off flavour.