Lecture 6

Enzymes

Enzymes are a group of proteins that have the ability to catalyze chemical reactions and the speed of such reactions. The action of enzymes is very specific. Milk contains both indigenous and exogenous enzymes. Exogenous enzymes mainly consist of heat-stable enzymes produced by psychrotrophic bacteria: lipases, and proteinases. There are many indigenous enzymes that have been isolated from milk. The most significant group are the hydrolases:

Lipoprotein lipase (LPL): A lipase enzyme splits fats into glycerol and free fatty acids. This enzyme is found mainly in the plasma in association with casein micelles. The milkfat is protected from its action by the FGM. If the FGM has been damaged, or if certain cofactors (blood serum lipoproteins) are present, the LPL is able to attack the lipoproteins of the FGM.

Plasmin: Plasmin is a proteolytic enzyme; it splits proteins. Plasmin attacks both ß -casein and alpha(s2)-casein. It is very heat stable and responsible for the development of bitterness in pasteurized milk and UHT processed milk. It may also play a role in the ripening and flavour of cheese.

Alkaline phosphatase: Phosphatase enzymes are able to split specific phosphoric acid esters into phosphoric acid and the related alcohols. The enzyme is destroyed by minimum pasteurization temperatures, therefore, a phosphatase test can be done to ensure proper pasteurization.

Lactose

Lactose is a disaccharide (2 sugars) made up of glucose and galactose (which are both monosaccharides). It comprises 4.8 to 5.2% of milk, 52% of milk SNF, and 70% of whey solids. It is not as sweet as sucrose. When lactose is hydrolyzed by ß -D-galactosidase (lactase), an enzyme that splits these monosaccharides, the result is increased sweetness, and depressed freezing point. One of its most important functions is its utilization as a fermentation substrate. Lactic acid bacteria produce lactic acid from lactose, which is the beginning of many fermented dairy products. Lactose is relatively insoluble which is a problem in many dairy products, ice

cream, sweetened condensed milk. In addition to lactose, fresh milk contains other carbohydrates in small amounts, including glucose, galactose, and oligosaccharides.

Vitamins

Vitamins are organic substances essential for many life processes. Milk includes fat soluble vitamins A , D, E, and K. Vitamin A is derived from retinol and ß -carotene. Because milk is an important source of dietary vitamin A, fat reduced products which have lost vitamin A with the fat, are required to supplement the product with vitamin A. Milk is also an important source of dietary water soluble vitamins: B1 – thiamine, B2 – riboflavin, B6 – pyridoxine, B12 – cyanocobalamin, niacin and pantothenic acid. There is also a small amount of vitamin C (ascorbic acid) present in raw milk but it is an insignificant amount relative to human needs and is quite heat-labile: about 20% is destroyed by pasteurization. The vitamin content of fresh milk is given below:

Vitamin	Contents per litre
A (ug RE)	400
D (IU)	40
E (ug)	1000
K (ug)	50
B1 (ug)	450
B2 (ug)	1750
Niacin (ug)	900
B6 (ug)	500
Pantothenic acid (ug)	3500
Biotin (ug)	35
Folic acid (ug)	55
B12 (ug)	4.5
C (mg)	20

Minerals

All 22 minerals considered to be essential to the human diet are present in milk. These include three families of salts:

1. Sodium (Na), Potassium (K) and Chloride (Cl): These *free* ions are negatively correlated to lactose to maintain osmotic equilibrium of milk with blood.

2. Calcium (Ca), Magnesium (Mg), Inorganic Phosphorous (P(i)), and Citrate: This group consists of 2/3 of the Ca, 1/3 of the Mg, 1/2 of the P(i), and less than 1/10 of the citrate in *colloidal* (nondiffusible) form and present in the casein micelle.

3. *Diffusible* salts of Ca, Mg, citrate, and phosphate: These salts are very pH dependent and contribute to the overall acid-base equilibrium of milk. The mineral content of fresh milk is given below.

Mineral	***Content per litre***
Sodium (mg)	250-640
Potassium (mg)	1100-1500
Chloride (mg)	800-1200
Calcium (mg)	1100-1300
Magnesium (mg)	70-140
Phosphorus (mg)	800-1000
Iron (ug)	100-700
Zinc (ug)	2500-7000
Copper (ug)	100-350
Manganese (ug)	10-50
Iodine (ug)	50-600
Fluoride (ug)	20-80
Selenium (ug)	20-40
Cobalt (ug)	0.5-1.3
Chromium (ug)	0.5-20
Molybdenum (ug)	20-100
Nickel (ug)	0-50
Arsenic (ug)	20-60
Aluminum (ug)	50-1600
Lead (ug)	tr-20

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