Paper No.: 07

Paper Title: TECHNOLOGY OF MILK AND MILK PRODUCTS

Module – 2: Role of milk and milk products in our diet

INTRODUCTION

Milk and other dairy foods were recognized as important foods as early as 4000BC, evidenced by rock drawings from the Sahara depicting dairying. 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

Milk and milk products in the form of food not only meet the nutritional requirement but also supplement the following requirements.

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

NUTRIENT COMPONENTS OF MILK AND MILK PRODUCTS

Although fluid whole milk is a liquid food (87% water), it contains an average of 13% total solids and 9% solids-not-fat, an amount comparable to the solids content of many other foods. More than 100 different components have been identified in milk. Important nutritional contributions of milk and milk products are calcium, protein, potassium, vitamin A, vitamin B12, riboflavin, niacin (or niacin equivalents), and phosphorus.

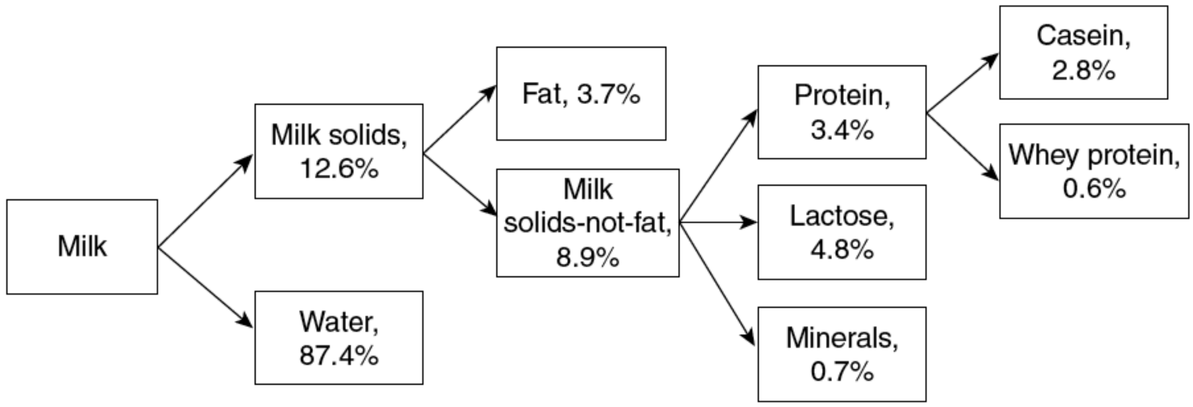

Figure 1 Major constituents of milk

(From Chandan, R., Dairy-Based Ingredients, Eagan Press, St. Paul, MN, 1997**)**

ENERGY

The energy (calorie) content of milk and other dairy products varies widely and depends mostly on the fat content of the milk, but also on the addition of nonfat milk solids, sweeteners, and other energy yielding components.

FAT

Milk fat contributes unique characteristics to the appearance, texture, flavor, and satiability of dairy foods, and is a source of energy, essential fatty acids, fat-soluble vitamins, and several other potential health-promoting components. The rich and pleasant flavor 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. Nutritive value of milk fat is due to its high calorie value of 9 kilocalories per gram.

Milk fat exists in microscopic globules in an oil-in-water emulsion in milk. Milk fat is made up of mainly triglycerides (97% to 98% of total lipid). Remaining 2 – 3% constitute phospholipids, cholesterol and cholesterol esters, diacylglycerols, monoacylglycerols, free fatty acids, fat soluble vitamins A, D, E, and K.

Fatty acids and fatty-acid derivatives with 4 to 26 carbon atoms are present in milk fat. Milk fat contains relatively high proportion of short-chain and medium-chain saturated fatty acids (i.e., those with 4 to 12 carbons in length). These fatty acids are present as saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids.

The saturated fatty acids (palmitic, stearic, and myristic acids) generally contribute to an increase in blood cholesterol levels. Long-chain saturated fatty acids such as lauric, myristic, and palmitic acids raise blood cholesterol levels, whereas stearic acid and short-chain saturated fatty acids such as butyric, caproic, caprylic, and capric acids have either a neutral effect or may lower blood cholesterol levels. Findings from cell culture and experimental animal studies indicate that butyric acid may protect against some cancers. In a variety of cancer cell lines (colon, leukemia, prostate, breast), butyric acid inhibits the proliferation and induces differentiation and programmed cell death (apoptosis).

Oleic acid is the main monounsaturated fatty acid in milk fat. Polyunsaturated fatty acids, such as arachidonic acid, are present in trace amounts. Linoleic and linolenic acids are not synthesized in the human body or are synthesized at such a slow rate that they must be supplied by the diet.

Trans fatty acids are naturally present in very small amounts in milk and dairy foods as a result of biohydrogenation in ruminants. The predominant trans fatty acid in milk fat, transK11-18:1 (vaccenic acid), is converted to conjugated linoleic acid (CLA), specifically cis-9, trans-11 CLA (rumenic acid). Findings from experimental animal, cell culture, and limited human studies demonstrate that CLA may help reduce the risk of several types of cancer (e.g., colorectal, breast, lung, prostate, ovarian), heart disease and diabetes, enhance bone formation and immune function.

Cholesterol is present in milk in relatively small concentration (less than 0.5% of milk fat). Cholesterol is very essential in the body as it is the precursor of many important substances, such as adrenocortical hormones, vitamin D, bile salts, and sex hormones. Milk and other dairy foods contributed about 16% of the cholesterol available in the food supply.

In vitro and experimental animal studies indicate that dietary sphingolipids may have a protective role in some cancers and possibly cardiovascular disease.

MILK PROTEIN

Milk is recognized as an excellent source of high-quality protein. Whole milk contains about 3.5% protein by weight, which accounts for about 38% of the total solids-not-fat content of milk, and contributes about 21% of the energy of whole milk.

Milk also contains small amounts of various enzymes and traces of nonprotein nitrogenous materials. Milk contains proteins in the form of casein and whey proteins. Of the total protein in milk, about 80% is casein and 20% is whey protein. Casein can be fractionated into four major components: alpha-, beta-, gamma-, and kappa-casein.

Whey protein, which is more heterogeneous than casein, consists predominantly of beta-lactoglobulin and alpha-lactalbumin. Alpha-lactalbumin has a high content of the amino acid tryptophan, a precursor of niacin. Other whey proteins present in smaller amounts are serum albumin, immunoglobulins (e.g., IgA, IgG, IgM), protease peptones, lactoferrin, and transferrin. Each of these proteins has unique characteristics and biological functions.

Milk protein is considered to be high-quality or a "complete protein," because it contains, in varying amounts, all nine of the essential amino acids (tryptophan, phenylalanine, lysine, threonine, valine, methionine, leucine, arginine and histidine) that human bodies cannot synthesize.

Benefits of bovine milk-derived peptides and amino acids in glycemic control and weight management, food intake regulation, muscle metabolism, hypertension, and reduction of dental caries have been proved through various research studies.

Dairy foods are rich in the branched-chain amino acid leucine, which has role in recovery of muscle protein synthesis during food restriction (dieting) or after endurance exercise.

Milk proteins are rich source of peptides that inhibit the vasoconstrictor angiotensin-I-converting enzyme and significantly lower systolic and diastolic blood pressure.

On the negative side milk proteins have allergic property A limited number of infants and young children exhibit allergic responses to bovine milk protein, primarily beta-lactoglobulin, casein, alpha-lactalbumin, and bovine serum albumin.

CARBOHYDRATE

Lactose is the principal carbohydrate present in milk. It is synthesized in the mammary gland. Lactose accounts for approximately 54% of the total solids-not-fat content of milk and contributes about 30% of the energy (calories) of whole milk. Carbohydrate provides energy at the rate of 4.0 kilocalories per gram.

Lactose favors the intestinal absorption of calcium and perhaps phosphorus in infants. Lactose helps in the absorption of calcium by its chelating action. This action of lactose is through the absorption of calcium as calcium lactate. In addition, some of the lactose enters the distal bowel (colon), where it promotes the growth of certain beneficial lactic-acid-producing bacteria that may help combat gastrointestinal disturbances resulting from undesirable putrefactive bacteria.

The mechanism behind this is, intake of lactose through milk 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.

Minor quantities of glucose, galactose, and oligosaccharides are also present in milk. Glucose and galactose are the products of lactose hydrolysis by the enzyme lactase. Researchers speculate that galactose may have a unique role in the rapidly developing infant brain.

Some individuals have difficulty digesting lactose because of reduced lactase levels, a condition called lactase nonpersistence or lactose intolerance. During the ingestion of lactose in small intestine it is broken down to glucose and galactose by the enzyme lactase, also called β-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 intolerance can be overcome by either avoiding taking milk or consuming hydrolytic milk products such as dahi, yoghurt, lassi etc.

VITAMINS

Almost all of the vitamins known to be essential to humans have been detected at some level in milk. Milk and its products contain both water soluble and fat-soluble vitamin.

Vitamins A, D, E, and K are associated with the fat component of milk. Vitamin A plays important roles in vision, gene expression, cellular differentiation, embryonic development, growth, reproduction, and immunocompetence. Both vitamin A and its precursors, called carotenoids - principally beta-carotene – are present in variable amounts in milk fat.

Vitamin D, a fat-soluble vitamin that enhances the intestinal absorption of calcium and phosphorus, is essential for the maintenance of a healthy skeleton throughout life. A deficiency of this vitamin results in inadequate mineralization of bone and leads to the development of rickets in children and osteomalacia in adults. In addition, vitamin D deficiency leads to secondary hyperparathyroidism, which enhances mobilization of calcium from the skeleton, resulting in osteoporosis.

Vitamin E (mainly tocopherol) is an antioxidant, protecting cell membranes and lipoproteins from oxidative damage by free radicals. This vitamin also helps to maintain cell membrane integrity and stimulate the immune response. Some studies also support a protective role for vitamin E in cardiovascular disease and possibly some cancers.

Vitamin K, which is necessary for blood clotting, is found in low concentrations in milk.

In addition to the essential fat-soluble vitamins, milk and other dairy foods also contain all of the water-soluble vitamins in varying amounts required by humans. Significant amounts of thiamin (vitamin B1), which acts as a coenzyme for many reactions in carbohydrate metabolism, are found in milk.

Milk is also an excellent source of riboflavin, or vitamin B2. This vitamin functions as a precursor for certain essential coenzymes important in the oxidation of glucose, fatty acids, amino acids, and purines.

Niacin (nicotinic acid and nicotinamide) functions as part of a coenzyme in fat synthesis, tissue respiration, and utilization of carbohydrate. This vitamin promotes healthy skin, nerves, and digestive tract, as well as aiding in digestion and fostering a normal appetite.

Milk is a good source of pantothenic acid, a component of the coenzyme A involved in fatty acid metabolism.

Vitamin B6 (pyridoxine, pyridoxal, pyridoxamine) functions as a coenzyme for more than 100 enzymes involved in protein metabolism.

Folate (folic acid) is a growth factor and functions as a coenzyme in the transfer of one-carbon units in the de novo synthesis of nucleotides necessary for DNA synthesis.

Vitamin B12 is necessary for growth, maintenance of nerve tissues, and normal blood formation.

Ascorbic acid (vitamin C), which forms cementing substances such as collagen in the body, is important in wound healing and increasing resistance to infections. This vitamin also enhances the absorption of nonheme iron and may protect against some cancers and cardiovascular disease. Milk contains an insignificant amount of vitamin C.

MINERALS

Milk and other dairy foods are important sources of major minerals, particularly calcium, phosphorus, magnesium, potassium, and trace elements such as zinc. The mineral content of milk is influenced by several factors, including the stage of lactation, environmental influences, and genetics. For this reason, there may be wide variation in the content of specific minerals in milk.

Milk and other dairy products are an excellent source of readily bioavailable calcium. About 99% of the body's calcium is found in bone and teeth, with the remaining one percent in body fluids, nerves, heart, and muscle. Throughout life, calcium is continually being removed from bones and replaced with more calcium. Consequently, the need for an adequate supply of dietary calcium is important throughout life, not only during the years of skeletal development. In addition to calcium's beneficial role in bone health, this mineral fulfills several other important physiological functions in human metabolism, as evidenced by its role in blood coagulation, myocardial function, muscle contractility, and integrity of intracellular cement substances and various membranes.

Milk is also an important source of phosphorus. This essential mineral plays a central role in metabolism and is a component of lipids, proteins, and carbohydrates.

Magnesium, a required cofactor for over 300 enzyme systems in the body, is related to calcium and phosphorus in function. This mineral activates many of the body's enzymes, participates in the synthesis of protein from amino acids, and plays a role in the metabolism of carbohydrate and fat.

Potassium contributes to the transmission of nerve impulses and helps to control skeletal muscle contraction. Accumulating scientific evidence supports a beneficial role for potassium in blood pressure control or prevention of hypertension.

Milk and other dairy foods contain many trace elements or nutrients needed by the body at levels of only a few milligrams per day. Of the more than 100 known trace elements, dietary recommendations have been established for relatively few trace elements (e.g., those considered to be of nutritional importance, such as iron, zinc, selenium, iodine, fluoride, boron, chromium, copper, manganese, molybdenum, nickel, and vanadium).

Iron is found in low concentrations in milk.

Zinc is a constituent of nearly 100 enzymes involved in most major metabolic pathways, such as the synthesis of ribonucleic acid, deoxyribonucleic acid, and protein. This trace element is essential for growth and development, wound healing, immunity, and other physiological processes.

Selenium functions largely through an association with proteins or selenoproteins. For example, selenium is an integral component of the selenoprotein glutathione peroxidase which helps to protect cell components from oxidative damage.

Iodine, which occurs naturally in milk, is an essential component of the thyroid hormones thyroxine and triiodothyronine, which regulate growth and metabolism.

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