Whey Proteins: Nutritional Properties

Food contains various nutrients. Proteins are one of the most important nutrients. It is required for many functions in the body. Proteins in the diet make proteins in the body like skin, hair, bone, muscle proteins. Enzymes and antibodies in body are made of proteins. There are many other functions of proteins like storage, hormones, transport in body fluids, blood clotting etc. Not counting water, 75 percent of the human weight is protein. Virtually every body part or tissue has protein component.

It has been estimated that dietary requirements of humans is about 1 g protein per kg body weight. Lack of protein in diet of children can cause growth failure, loss of muscle mass, decreased immunity, weakening of the heart and respiratory system and finally death. Protein malnutrition leads to a condition known of kwarshiorkor, which is affecting millions of people mostly children around the world.

Proteins are available from different dietary sources like meats, eggs, grains, legumes and milk products. Different proteins have different proportions of amino acids, some being essential amino acids and that proportion decides the quality of the protein with respect to human requirements. Milk, egg, meat and soy proteins have very high quality due to the higher proportions of essential amino acids. Even these proteins are mixtures of proteins, each having different amino acid composition and so different quality and some even have certain biological activity important from the health point of view.

Milk: An Excellent Source of Nutrients

Bovine milk has been consumed by humans ever since domestication of cattle and is considered one of the most nutritious foods even for children. Milk has an excellent nutrient profile and provides various macro and micro-nutrients that are essential for them. It provides significant amounts of high quality protein, calcium, riboflavin, magnesium, phosphorus, niacin, vitamin B12, vitamin B6, vitamin A as well as several other essential nutrients. Comparing the calories provided by milk with the high levels of nutrient contents that are delivered, milk is a very nutrient dense food. When some of the products like skim milk, low fat milk and buttermilk are considered, these have much lower calorie contents, so their nutrient density is even higher.

One of the important nutrients in milk is the high quality protein. Bovine milk is an excellent source of protein, and provides various amounts of all of the essential amino acids that humans can not synthesise and are essential amino acids. In proportion, the amino acid composition resembles amino acid requirements of humans. Cow's milk protein is rich in lysine. Lysine is limiting in most plant proteins and so cow's milk complements these plant proteins elevating the nutritive value of these proteins.

Cow's milk proteins have one of the highest PER (Protein Efficiency Ratio) among all food proteins, with a value of 3.1. Another measure of protein value is PDCAAS (Protein Digestibility Corrected Amino Acid Score). Cow's milk PDCAAS is 1.21, next only to casein, the major milk protein (1.23). Thus milk proteins are quite nutritious and are used as ingredients in many products to make them more nutritious.

Cow's milk has 13% solids, of which about 27% are proteins. These are made up of two major protein groups, caseins, which account for 80% of milk proteins and whey proteins, which account for about 20%. Much of the studies were done earlier on milk proteins. However, because of technological advancements, it is now possible to prepare commercially various fractions of milk proteins. Lately many new studies have been conducted on whey proteins and their different fractions.

What are whey proteins

Milk has many proteins. If milk is acidified, group of proteins called caseins precipitate, while the whey contains another group of milk proteins, whey proteins. While casein comprise 80% of the total proteins, whey proteins only about 20%. Whey is commonly obtained as a by-product of cheese making. Whey also contains lactose, fat and other substances and is processed to prepare whey protein concentrate and whey protein isolate, which have much higher proportions of proteins.

The major whey proteins are β-lactoglobulin (65%), α-lactalbumin (25%) and serum albumin (8%). There are many minor proteins like immunoglobulins such as IgG, IgA and IgM, and glycomacropeptides, lactoferrin, lactoperoxidase, lysozyme etc.

There are many types of whey proteins commercially available in the market. Whey powder contains lactose and fat with a small percentage of proteins. In order to increase the concentration of proteins different techniques are used, yielding whey protein concentrates and isolates. During concentration of proteins, proportion of individual proteins may also change. Ion-exchange isolates are high in protein but low in glycomacropeptide, lactoferring, lactoperoxidase and some bioactive peptides. These smaller fractions are retained in microfiltration or ultrafiltration but these processes recover less bovine serum albumin. Cross-flow microfiltration can produce an isolate in which protein is undenatured and retain all the important smaller fractions in natural ratios.

Benefits of Whey Proteins

Whey protein has the highest biological value of all known food proteins and is also easily digestible. Whey protein in milk does not precipitate upon acidification or after adding rennet in cheese making. Heating at sufficiently high temperature, will however, denature it leading to precipitation. Commercial whey protein is available in three forms: concentrate, isolate and hydrolysate with large number of sub-forms.

Concentrates normally have protein contents of 29-89%, isolates have 90% and more, while hydrolysates are partially hydrolysed (pre-digested) whey proteins.

Whey proteins have been used as highly nutritious food ingredients. Physically they are quite different in body from caseins. Micellar casein clots in stomach and this slows their movement to small intestine. Whey proteins reach small intestine quite rapidly. This difference influences whole body protein synthesis.

Whey proteins β-lactoglobulin, α-lactalbumin, lactoferrin and immunoglobulins have been shown to be present intact in the intestinal lumen. Lactoferricin formation from lactoferrin within the human stomach, as well as in the intestine of rat model has been demonstrated. Some dietary proteins and polypeptides reach the intestinal mucosa in significant amounts and may be absorbed intact. This was shown for β-lactoglobulin, α-lactalbumin, lactoferrin and prolactin but not for casein. Absorption of large molecules in antigenic and biologically active quantities plays a role in different physiological and immunological responses.

The nature of whey protein digestion appears to contribute to retention of whey protein and peptide bioactivity within the gut, that can provide passive protection against infection, modulate digestive and metabolic processes and act as growth factors.

Whey proteins have many applications because of the digestibility, very high biological value and PER, some very key amino acids including branched chain amino acids, minor proteins and enzymes having physiological acitivity etc. Some of the areas having application are child nutrition, senior nutrition, sports nutrition, weight control and cardiovascular health etc.

Child Nutrition

Mother's milk is ideal for infants. When it is inadequate or not available, infant formula is recommended. Manufacturers have been increasingly adding whey proteins to cow's milk based infant formula to simulate human milk, which is high in whey proteins. Infants with colic and allergy to cow's milk protein also respond well to whey protein. In case of allergy, hydrolysed whey protein is used. This is not only because of high biological value but also whey protein hydrolysates have better taste compared to casein hydrolysates.

Human milk contains a large number of antibodies, functional enzymes, growth factors, gastrointestinal protective factors, functional immune cells and non-protein nitrogen sources important for infants.

Human milk is the best food for infants. Its composition is thought to have evolved on nutritional compromise between mother and infant, with antibodies for pathogens encountered by mother and which are important for the survival of infant. The presence of various functional substances and protective factors in human milk makes it a complex but highly desirable infant food. Infant food manufacturers must appreciate this. Most of the infant formulae rely upon products that are based on cow's milk protein. Some desirable components of human milk e.g. pathogen specific human milk immunoglobulins, are either too variable or expensive to add to infant formula. Cow's milk itself does not match human milk in some other respects too. One major difference is the whey protein content.

Human milk predominantly contains whey proteins, while the major protein in cow's milk is casein. Whey to casein ratio of mature human milk is 60:40 and that of cow milk is about 20:80. Therefore some manufacturers have attempted to prepare humanised milk by adding whey protein to cow's milk. Commonly, 6g of whey protein may be added to 9g cow's milk protein.

Even whey composition is different in cow's milk. Human whey has more of α-lactalbumin and lactoferrin. Currently enrichment of these in cow's milk by fractionation technology is not feasible. Human milk produces different plasma essential amino acid profile in the infant than cow's milk or whey protein infant formula. Hence, infants will benefit from improvements that will match closer the plasma essential amino acid profile of breastfed infants, considering that amino acids have functions other than protein synthesis, including synthesis of hormones, bile acids and neurotransmitters. One example is of tryptophan that gets converted to serotonin and melatonin, which affect sleep behaviour. Sleep latency is reduced in infants that are fed supplemental tryptophan.

Most formulae for premature infants are whey-predominant having whey to casein ratio of 60:40. Casein predominant formulae are thought to lead to excessive plasma concentrations of tyrosine and phenylalanine. Those fed whey-predominant formula had metabolic responses similar to those premature infants fed pooled human milk.

While protein needed per body weight is lower in older infants and young children, their daily requirement is higher. As per Codex guidelines, products meant for this group should contain 15g of high quality protein per 100g. Use of whey protein helps provide such protein rich in essential amino acids.

Senior Nutrition

As people age, changes in their metabolism and activity together with changes in body composition and various physiologic functions. Body fat increases due to decreased physical activity, reduction in metabolic rate and consumption of excess calories. There is also loss of muscle or sarcopenia and among many causes are effects of dietary protein intake and reduced activity level.

Aging leads to decrease in neural and muscular function. This change causes progressive and costly disability and dependence. By 70-80, both men and women experience almost a third or more decrease in muscle strength. Sarcopenia results from loss of muscle mass rather than from loss of strength per unit of muscle. Loss of muscle mass secondary to decreased motor neuron activity appears to be the major causative factor. Other factors are decreased protein intake, decreased caloric intake, altered protein synthesis and decreased physical activity. Postprandial stimulation of protein synthesis is reduced in healthy seniors and can be stimulated by whey protein better than any other protein.

Sufficient intake of protein is very important especially in overweight elderly as weight loss is to be achieved without decreasing muscle mass. Whey protein is a rich source of essential and branched chain amino acids, both of which contribute to better post-prandial protein synthesis and maintenance of muscle. Therefore during weight-control diet muscles are not wasted if whey protein is provided.

Recently, increased dietary intake of protein has been shown to reduce bone mineral loss and risk of fracture in older women due to its effect on calcium metabolism. Although very high protein intakes increase urinary calcium excretion, protein intakes of 0.7-2.1g/kg improve the intestinal calcium absorption. Animal protein has more protective role than vegetable protein and whey protein being most acceptable at high levels in this respect.

Whey protein contains β-lactoglobulin, α-lactalbumin, immunoglobulins, lactoferrin, lactoperoxidase, glycomacropeptide etc. These proteins possess antioxidant, anticancer, antihypertensive, antihyperlipidemic, antimicrobial and antiviral properties. Thus consumption of these biologically active proteins and peptides may promote general health in seniors in many ways. Seniors are prone to a variety of diseases due to the reduced resistance and they need all the protection they can get from these health promoting substances present in whey in order to combat old age diseases like cardiovascular diseases, cancer, hypertension, and a horde of infections.

Sports Nutrition

Whey protein concentrate and isolate not only provide a very good source of high quality protein with minimal fat and carbohydrate, they can promote immunity, efficient muscle recovery and extend the overall health benefits of physical activity.

Stimulating protein synthesis and minimising protein breakdown are essential for efficient recovery after a vigorous exercise. The protein must have high digestibility and proper composition of amino acids to promote resynthesis. Research studies show whey proteins to be the most effective in promoting mechanisms that favour efficient recovery and better results from exercise training.

Amino acid profile of whey proteins is very similar to skeletal muscle. Essential amino acids are indispensable for stimulating rapid protein synthesis in adult muscles and whey protein has very high proportion of these. Whey proteins contain high levels of branched chain amino acids (BCAA), which play a critical role in muscle energy production and recovery.

Glutathione is a critical substance during an intense physical activity of many sports. Maintenance of glutathione concentration within body is critical in endurance as well as intense exercises. Supplementation with whey protein during such activities has been shown to prevent a decline in blood glutathione level.

Whey proteins are also known to improve muscle strength so the performance of athletes is improved. It is important for athletes to have adequate stores of glycogen in tissues to avoid fatigue and poor performance. One study showed that diet rich in whey protein results in higher glycogen storage in liver during exercise, a condition conducive for better performance in sports.

Whey proteins have many advantages and many products contain these as ingredients. Many studies have been conducted on chemistry and physiological properties of whey proteins. Technological advances will enable separation of smaller fractions of the whey proteins. This will allow design of many products with specific applications.

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