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Nutritional and Medical Perspectives of Whey Protein: A Historical Overview

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ABSTRACT

Whey nowadays considered as nutritional power house of future. Presently, whey mainly used as energy base drinks for sportsman and for therapeutic application in many countries. The two primary sources of protein in milk are the caseins and whey. After processing occurs, the caseins are the proteins responsible for making curds, while whey remains in an aqueous environment. Whey protein is a reliable source of amino acids and biologically active proteins which act as a nutritional supplement. The components of whey include beta lactoglobulin, alpha lactoalbumin, bovine serum albumin, lactoferrin, immunoglobluins, lactoperoxidase enzymes, glycomacropeptides, lactose, and minerals. Whey proteins have a high amount of branched chain amino acids such as leucine, isoleucine, and valine. These are also rich in the sulfur-containing amino acids cysteine and methionine, which enhance immune functions through their intracellular conversion to glutathione. The present review paper gives information about the potential beneficial properties of whey protein and focuses on using whey protein supplementation as an immuno-modulator, antioxidant, anti-inflammatory, anti-diabetic, anti-cancer. In this context, the current review presented that whey protein supplementation is shown to maintain a high concentration of cellular antioxidants and boost immune defenses that promote carcinogen detoxification. Due to the positive findings, whey protein supplementation is starting to be viewed as a non-pharmaceutical adjunct therapy in the treatment of cancer. Also, whey protein provides an abundant supply of essential amino acids to organs and tissues, which stimulate tissue regenerative mechanisms and help minimize immune suppression.

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Introduction

Whey a by-product of cheese manufacturing was once considered a waste product. In past 20 years, recent advances and research made whey a co-product and its recognition as a functional food with nutritional application (1, 2). Since the early 1980's, whey has become a popular dietary protein supplement purported to provide antimicrobial activity, immune modulation, improved muscle strength and body composition, and prevention of cardiovascular diseases. Whey now-a-days considered as nutritional power house of future (3). Whey based products such as whey drinks and concentrates stability concerns during storage. Its stability effects during different storage temperatures (4).

Presently, whey mainly used as energy base drinks for sportsman and for therapeutic application in many countries. The two primary sources of protein in milk are the caseins and whey. After processing occurs, the caseins are the proteins responsible for making curds, while whey remains in an aqueous environment (5). The components of whey include beta-lactoglobulin, alpha-lactalbumin, bovine serum albumin, lactoferrin, immunoglobulins, lactoperoxidase enzymes, glycomacropeptides, lactose, and minerals (1). The scientific

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literatures contain numerous references to whey protein functionality and nutritional research.

The main emphasizing objective of this review study is to provide a beneficial approach concerning with nutritional value of whey protein and to lighten up whey protein clinical importance such as anti-diabetics, anti-cancerous and uses against disease. Considering the enormous nutraceutical worth of whey protein, this review emphasizes on its established and emerging biological roles. Present and future scopes in food processing and dietary supplement formulation are discussed in this article.

Whey Protein composition

The components of whey include beta lactoglobulin, alpha lactoalbumin, bovine serum albumin, lactoferrin, immunoglobluins, lactoperoxidase enzymes, glycomacropeptides, lactose, and minerals (6). Whey proteins have a high amount of branched chain amino acids such as leucine, isoleucine, and valine. These are also rich in the sulfur-containing amino acids cysteine and methionine, which enhance immune functions through their intracellular conversion to glutathione (7). The primary components of whey protein with their benefits are listed in Table 1 as described by Bilsborough and Mann, (2006) (8); Smithers, (2008) (6).

Table 1. Primary Components of Whey Protein.

Whey Component	% of Whey Proteinw	Benefits
Beta-lactoglobulin	50-55%	Excellent source of essential and branched chain amino acids which spares muscles and glycogen during exercise Binds fat soluble vitamins, increasing bioavailability
Alpha-lactoalbumin	20-25%	Primary protein in human breast milk Excellent source of essential and branched chain amino acids High in the essential amino acid tryptophan, which helps in regulating sleep, mood and stress
Immunoglobulins	10-15%	IgA, IgD, IgE, IgG ,IgM-Primarily IgG Primary protein found in colostrum Immune enhancing benefits to all ages, maturity, particularly in infants
Glycomacropeptides	10-15%	Does not contain amino acid phenylalanine, so is often used in infant formulas with phenylketonuria Inhibits formation of dental plaque and cavities
Bovine Serum albumin	5-10%	Large-sized protein having good profile of essential amino- acids Fat-binding properties in body
Lactoferrin	1-2%	As Antioxidant found in breast milk, tears, saliva and blood Promotes growth of beneficial bacteria Antiviral, antibacterial, antifungal Regulates iron absorption and bioavailability
Lactoperoxidase	0.5%	Inhibits growth of bacteria

Whey Protein base products

In the late 1980's, whey due to its nutritive value and beneficial functions become interesting study subject. Development of membrane fractionation techniques including ultra-filtration, reverse osmosis and microfiltration, enabled production of wide range of whey protein products, such as whey powder, whey protein concentrate (WPC), whey protein hydrolysate (WPH), whey protein Isolate (WPI) and pure forms of lactoalbumin, immunoglobulins and lactoglobulins (9).

Whey Protein nutritional aspects

Whey protein is a complete and rich in amino acid protein. It contains a high profile of essential amino acids and branched chain amino-acids which are important for growth and repair of tissue. Leucine is a key branched chain amino acid (BCAAs) in whey proteins synthesis which plays a role in insulin and glucose metabolism (10). The essential amino acids (EAAs) and BCAAs in whey are not only present in high concentration but also absorb and utilize in body more than other protein sources such as wheat, corn and soy (11).

Whey Protein role in body composition

Whey having high concentration of EAAs and BCAAs, has been shown to help for maintaining muscle tissues. It is important for adult's health and for active individuals, and also for those trying to maintain or lose their weight (12).

Adult's health maintenance by Whey Protein

Whey helps in increasing or maintaining lean body mass of adults which ultimately leads to protection against in many changes of body composition as well as immunity against many aging associated diseases such

as heart stroke and disease, diabetes and other unhealthy conditions. One mainly associated diseases of aging is Sarcopenia- affects mostly adults and causes muscle loss associated with aging (13). Recent research in older adults proposed that whey protein may minimize Sarcopenia by stimulating postprandial protein synthesis and limiting body protein losses (14).

Daily exercise or physical activity with combination of whey protein gives additional benefit on muscle protein synthesis. In-taking about 10-20 grams of whey protein causes high level and efficient absorption of EAAs and leucine in adult's body leading to improve whey protein synthesis (15).

Whey Protein role in weight management

Whey plays important role in weight management. Specific factors studied in whey protein have proved that they contribute to weight loss by increasing satiety, maintaining lean body mass and having an influence on glucose homeostasis levels (16). Whey components also contribute to weight management, some components present in whey proteins and their role is described as:

Lactose- it is primary sugar in whey products- it also has low glycemic index which helps in promoting weight loss and controlling hunger. Lactose has less effect on increasing blood sugar levels and insulin, so making it deal with type II diabetes for people (17).

Branched Chain Amino Acids (BCAAs) - especially leucine, plays a role in regulation of metabolism by promoting lean muscle tissue with a daily followed exercise program. It also helps in fat loss (18).

Protein- it helps in increasing satiety and promotes loss of body fat and weight by maintaining energy intakes. Many studies have shown that proteins are more effective than egg, meat and soy proteins in suppressing food intake (19). So for people who want moderate carbohydrate diets and high proteins, it is an ideal solution for them to incorporate or make it a part of their diets.

Calcium- adequate intake of calcium may protect against adiposity or assist in loss of weight. By Epidemiological studies it has proven that low intake of calcium can increase risks of obesity (20).

Whey Protein role in sports nutrition

Many sports athletes already consuming whey protein as it is rich in BCAAs profile. Because as the intensity of exercise increases requirement for BCAAs increases so whey proteins are the best way to replace these BCAAs to enhance protein synthesis and growth of muscles during recovery period as whey proteins have identical amino acids profile to skeletal muscles so it helps in muscles growth (21).

Also high levels of EAAs are effective in synthesis and stimulating of proteins in adult muscles. Recent studies have proposed that whey proteins help in improving lean body mass and performance in athletes when a resistance training program is followed, some studies concerning with whey intake by athletes during training regime are:

Enhancement of glutathione status (an antioxidant) by taking 20 grams of whey protein per day for 12 weeks improves athletic performance and minimizes the body fat percentage in healthy young athletes and also in adults (21). Intake of about 60 grams of whey protein per day for 12 weeks proved effective in decreasing body fat and increasing lean body mass in overweight men following a calorie restricted diet and resistance training program (22). Resistance-trained men with whey protein supplement intake of 1.5g/kg of body per day for 11 weeks showed improvements in strength and doubling their lean body mass as compared to those groups which were using different carbohydrates, creatine or combination of creatine and whey protein supplements (23).

Whey Proteins role in improving immune system

Whey proteins have ability to maintain body immune system primarily by boosting glutathione (GSH) levels in many tissues. GSH, which is centerpiece of the body's antioxidant system, protects body cells and tissues against UV exposure, toxins pollution or from radical damages (24). GSH levels may decrease due to cancer, chronic fatigue syndrome, HIV and other immune-compromising conditions. It also decreases with age or partially due to many diseases like Parkinson's disease, arteriosclerosis, Alzheimer's disease and cataracts (25). So whey usage in diet protects immune system form decreasing GSH levels in body. Components of whey protein which play important role in enhancing immune system includes:

Lactoferrin- it has ability to show activity of both antimicrobial and antitoxin that leads to immune-modulating activity. It also provides protection against hepatitis, influenza and cytomegalovirus (26).

Immunoglobulin- it provides protection to infants against diseases through passive immunity. In adults, helps in increasing the activity level of the immune system (26).

Branched Chain Amino Acids (BCAAS) - these amino acids metabolize by muscles for manufacturing of glutamine which is a precursor of glutathione and also a specific component of immune system (27).

Cysteine- it is an amino acid of whey protein present in high levels. It also involves in intracellular production of glutathione (GSH) (21). This study support, indirectly, a role for whey proteins in enhancing tissue glutathione levels and thus providing a degree of protection against tumor development.

Whey Protein medical perspectives

Anti-Cancer

Dietary whey proteins are shown more protective against the development of intestinal cancers and play a protective role for dietary dairy proteins against tumor development. Dietary proteins differ in their ability to protect against cancer development and that the proteins in dairy foods, particularly the whey proteins, appear to play a significant role in cancer prevention. Dietary WPC has potent anticancer properties against colon cancer (28).

Table 2. Whey Proteins products and their uses.

Whey Products	Fat (percentage by weight)	Lactose (percentage by weight)	Protein concentration (percentage by weight)	Applications
Whey Powder	1-1.5%	63-75%	11-14.5%	Production takes place by taking whey directly from cheese production, clarifying, pasteurizing, and drying. Use in bakery, breads, dairy foods and in different snacks.
Whey Protein Concentrates (WPC)	1-9%	4-52%	25-89%	Common and affordable form of whey. Used in dairy foods, bakery, confectionary, chocolate bars, beverages, and in nutritional sports food products.
Whey Protein Isolates (WPI)	0.5-1%	0.5-1%	90-95%	Use in beverages, protein bars, protein supplementation products and in nutritional food products manufacturing.
Hydrolyzed Whey Protein Concentrate (WPH)	Less than 10% (varies with protein concentration)	Less than 8%	>80% (hydrolysis used to cleave peptide bonds)	Use in making of sports nutrition products.
Hydrolyzed Whey Protein Concentrate Isolate	0.5-1%	0.5-1%	>90%	Highly digestible form containing easy to digest peptides that reduces allergic reaction risks in susceptible individuals. Used in infant formulas and nutritional sport products.

In addition to research employing whole whey proteins, some studies have looked at individual whey proteins for their potential anticancer properties. Lactoferrin is an ironbinding minor glycoprotein present in bovine milk. A number of physiological roles have been suggested for lactoferrin (29), but it is likely to be the iron-binding properties that contribute to anticancer properties of this whey protein, since free iron may act as a mutagenic promoter by inducing oxidative damage to nucleic acid structure. In addition to its effect in dietary inclusion, there is some evidence that lactoferrin administered by a parenteral route may have important anticancer properties (30).

It is thought that lactoferrin may bind iron locally in tissues, therefore reducing the risk of oxidant-induced carcinogenesis (31). Bovine serum albumin (BSA) is another whey protein which may have anticancer properties. BSA has been shown to inhibit growth of the human breast cancer cell line MCF-7 cell line, when included in in vitro cell culture with tumor cells (32).

Mammary-derived growth inhibitor (MDGI) is a fatty acid-binding protein present in bovine whey in trace levels. MDGI has been shown to inhibit the proliferation of bovine and murine epithelial cell lines in vitro. It plays a role in limiting early formation of neoplasms in the intestinal epithelium. However, this remains to be determined experimentally, since MDGI and other low-molecular weight components are notoriously difficult to isolate and purify from bovine milk (33).

Anti-Diabetics

Obesity and type 2 diabetes mellitus (DM) have grown in prevalence around the world, and recently, related diseases have been considered epidemic. Obesity or DM-associated diseases have high cost of treatments. Whey protein usage in dietary manipulation has reached popularity because it has been suggested for the prevention and treatment of obesity and DM. Whey protein helps in maintenance of muscle mass; increases in the release of anorectic hormones such as cholecystokinin, leptin, and glucagon like-peptide 1 (GLP-1). It also decreases the orexigenic hormone ghrelin (34).

Whey provides human body less gain in weight and it act as in reduction of serum glucose in healthy individuals, reduction of impaired glucose tolerance in DM and obese patients (35). Experimental and epidemiological studies have indicated that eating patterns of foods with use of supplements like whey or other proteins reduce inflammation and cardiovascular risks (36). Further studies have shown that whey protein can also lead to reductions in inflammation, blood pressure and oxidative stress (37).

Several epidemiological studies have demonstrated that type 1 diabetes is associated with an up to 10-fold increase in the risk of cardiovascular (CV) disease (38). The predominant and independent risk factors for CV events in patients with type 1 diabetes is the duration of disease, glycemic control, hypertension, and the presence

of nephropathy (39). Protein intake in type 1 diabetes has proved to be a challenging area of research and it needs potential mechanism of action. Extensive work is still required to improve and prove the potential impacts of different protein sources (i.e. fish, dairy, whey protein, soy and grain) in these type I diabetes patients (40).

Usage of Whey Proteins

Whey proteins have numerous applications overall the world because of their high nutritional value and they also provide protection against many diseases (2). Some of the nutritional supplements and products made from whey proteins which are used on the daily consumption basis for human health are mentioned in Table 2 as described by Smithers, (2008).

Conclusion

The whey protein boosts the recovery from resistance exercise-injuries, stimulate gut physiology and protect skin against detrimental radiations. Apart from health benefits, whey protein has proved its suitability as fat replacer and emulsifier. Furthermore, its edible and antimicrobial packaging potential renders highly desirable in food as well as pharmaceutical sectors. Finally, whey protein is a reliable source of amino acids and biologically active proteins which act as a nutritional supplement. There is growing evidence that whey protein possesses therapeutic properties in different pathological conditions.

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