WHEY PROTEINS AND SENIORS NUTRITION

Richard B. Kreider, PhD, EPC, FACSM, FASEP
Professor & Chair,
Department of Health, Human Performance & Recreation
Center for Exercise, Nutrition & Preventive Health, Baylor University

Edited by Beate Lloyd, PhD, RD, LD
Global Research Solutions

A growing body of scientific evidence reveals that whey contains various bioactive components that may have a positive effect on loss of muscle mass, cardiovascular health, bone health, immunity and general health of adults as they mature.

Whey proteins seem to fit well the unique needs of seniors, who represent a growing segment of the population in many countries around the world.

Furthermore, whey proteins may help manage sarcopenia, the loss of muscle which affects 30% of the seniors population.

This review describes the properties of whey protein that may provide specific benefit to mature and senior adults, as well as proposed mechanisms for whey's mode of action.

Changes in metabolism and activity levels are associated with profound changes in body composition and various physiologic functions in individuals as they age. Body composition changes include increases in body fat and loss of muscle mass.

The deposition of fat appears to result from a combination of decreased physical activity, reduction in metabolic rate and consumption of excess calories. Although the loss of muscle, or sarcopenia, is multi-factorial, dietary protein intake and activity level appear to be important determinants.[1,2]

Sarcopenia is a common condition in mature adults with important consequences. The loss of muscle strength leads to significant independence, potential disability and the concomitant healthcare costs.

PROTEIN BASICS

Although, all proteins are constructed of linear chains of amino acids, each protein is comprised of a unique sequence of amino acids. In addition, protein derived from natural sources of protein (milk casein, milk whey, soy, etc.) is a characteristic and complex blend of individual proteins. For example, whey protein contains β-lactoglobulin, α-lactalbumin, immunoglobulins, albumin, lactoferrin, lactoperoxidase, and glycomacropeptide. As a result, the amino acid profile of a dietary protein can differ depending on the source from which the protein is derived (Table 1), and in some cases, on the isolation and processing methods used. An especially important aspect of amino acid profile is the content of essential amino acids, those the body can only derive from the diet. The quality of a protein is generally reflective of its content of essential amino acids and provides a relative measure of its ability to satisfy protein requirements. The nutritional value of protein sources are compared using measures of protein quality.

The quality of protein is classified by determining the Protein Efficiency Ratio (PER) or the protein digestibility corrected amino acid score (PDCAAS).[3] The PER of a protein is determined by evaluating the weight gain of growing rats fed a particular protein in comparison to the standard protein, casein. The PER value decreases as the concentration of essential amino acids become limiting to the growth rate of rats.

The higher the PER value, the greater the quality of the protein. A weakness of the PER measure is that growing rodents have different amino acid requirements than human beings. One example is the rat's higher requirement for methionine and cysteine driven by their amount of hair and more rapid growth rate. The PDCAAS is used to more accurately predict the essential amino acid requirements of humans. The amino acid profile of a protein is compared to the essential amino acid requirements in humans established by The Food and Agriculture Organization. Different proteins have different essential amino acid profiles, and therefore, different PER and PDCAAS quality ratings (Table 2).

Table 1: Approximate Protein Quality of Various Forms of Protein Found in Food and Supplements

Protein	PDCAAS*	PER
Wheat Gluten	0.25	-
Beef	1.00	2.9
Soy	1.00	2.1
Whole Egg	1.00	3.8
Milk Protein	1.00	3.1
Casein	1.00	2.5
Whey	1.14	3.2

Adapted from USDEC Reference Manual for U.S. Whey and Lactose Products, 2003. p. 65.

*Protein Digestibility Corrected Amino Acid Score

WHY WHEY PROTEIN?

Whey protein is one of the highest quality proteins available for commercial use. The basis for the high protein quality value of whey protein is that it contains higher concentrations of branched chain amino acids (BCAA) and essential amino acids than other sources of protein.[3] Additionally, whey protein contains a number of peptides and protein fractions that may promote general health and well-being.[4-6] The following describes some of the ways that these unique properties of whey protein can promote health for mature adults.

Help Manage Sarcopenia

Aging leads to loss of neural and muscular function that is associated with progressive and costly disability and dependence. By ages 70-80, both men and women experience a 20-40% decrease in muscle strength.[1] Approximately 30% of those 60 years or older have sarcopenia, and as our population continues to age the prevalence is likely to increase.[1] Sarcopenia appears to result from loss of muscle mass rather than loss of strength per unit of muscle. Loss of muscle mass secondary to decreased motor neuron activity appears to be the major causative factor. However, decreased protein intake, decreased caloric intake, altered protein synthesis and decreased physical activity play important roles in its etiology.[1,2] One aspect of protein synthesis that is altered in older individuals is synthesis occurring shortly after a meal, or postprandial protein synthesis. Postprandial stimulation of protein synthesis is reduced in healthy elderly compared to healthy, young individuals.[1,2] Recent research in mature adults suggests that whey protein stimulates postprandial protein gain and limits body protein loss better than casein.[7] This finding is consistent with previous findings in healthy younger individuals indicating that whey protein is rapidly digested, and stimulates protein synthesis to a greater degree than other forms of protein.[8-11]

The positive effects of physical activity and dietary protein on sarcopenia are cumulative.[2] Essential amino acids appear to be the primary determinant of the stimulatory effect of dietary protein on muscle protein synthesis in the elderly.[12] After physical activity, ingestion of 3 -6 grams of essential amino acids or 10-20 grams of whey protein can improve protein synthesis in both young and older individuals.[13-19] As previously reviewed, whey protein is the richest, commercially available source of essential amino acids.

Promote Weight Loss

High protein/low carbohydrate diets have received intense attention in the lay press. The scientific literature indicates that high protein/low carbohydrate diets are more effective in promoting weight loss and improving insulin sensitivity than high carbohydrate diets.[20-27] However, this literature is not well developed in those 50 years and older and does not describe effects of use for longer than 90 days.[28] Yet, it is clear that sufficient intake of protein for older individuals is important in the context of balanced diet. This is particularly important as the goal in the overweight elderly is to promote weight loss without decreasing muscle mass. As previously discussed, postprandial protein synthesis is reduced in the elderly and is improved by intake of essential amino acids. In addition, recent evidence has indicated that branched chain amino acids have additional metabolic roles important to the maintenance of muscle if present in the plasma and cells at concentrations beyond those required to support protein synthesis.[29] Whey protein is an especially rich source of both essential and branched chain amino acids. Further, a consequence of maintaining muscle mass is a higher resting energy expenditure[30] and improved insulin sensitivity; benefits that improve general health. For these reasons, whey protein should be considered to help maintain muscle mass in the overweight older individual.

Bone Health

Recent evidence has indicated that increasing dietary intake of protein reduces bone mineral loss and risk of fracture in older women.[31,32] Although high intakes of protein are known to increase urinary calcium excretion, more recent research indicates that intestinal absorption of calcium is also increased by protein intakes from 0.7 to 2.1 g/kg.[33] Animal protein appears to have a more protective role than vegetable protein. The challenge is to provide sufficient protein in vehicles with acceptable sensory attributes. Of the commercially available animal proteins, whey protein has the broadest range of food applications and is one of those with the highest consumer acceptability from a sensory standpoint.

Good Source of Biologically Active Proteins and Peptides

Whey protein contains β-lactoglobulin, α-lactalbumin, immunoglobulins, Beta-globulin, lactoferrin, lactoperoxidase, and glycomacropeptide. Extensive literature describes the biological activity of each of these proteins (Table 3). Studies have indicated that proteins found in whey may possess antioxidant, anticancer, antihypertensive, antihyperlipidemic, antibacterial, antimicrobial, and antiviral properties.[4,34-36] Some of these proteins bind to vitamins and minerals and therefore play an important role in nutrient metabolism.[37,38] Whey proteins and peptides have also been reported to enhance digestion and gut function[6,39] as well as glutathione production and immune function.[40-44] Consequently, increasing dietary availability of these biologically active proteins and peptides may promote general health in a variety of ways.

Bone Health – Source of Calcium

The recommended calcium intake for adults over 51 is 1,200 mg/day. Whey protein provides about 500-800 mg of calcium per 100 g protein depending on the type of whey product considered. Whey protein can serve as a good source of dietary calcium. Increasing calcium intake may benefit elderly adults in two ways. First, calcium is often recommended as a means of maintaining bone mass. Second, research has indicated that calcium modulates a form of vitamin D which serves to regulate intracellular calcium levels in fat cells.[45] Dietary calcium has been shown to suppress fat cell growth and weight gain during periods of high caloric intake.[45] Further, increasing calcium intake has been shown to increase fat metabolism (lipolysis) and preserve thermogenesis during caloric restriction.[45]

The diet of seniors tends to be low in protein, and emerging data are beginning to suggest that recommended protein intakes should be increased as one ages.[46] Supplementing the diet of older individuals with protein following exercise can help maintain muscle mass, an important determinant of health. Whey protein is an ideal protein source because the effect on muscle mass is driven by essential amino acids. By implication, increasing intake of whey protein during illness, following surgery, and/or while undergoing chemotherapy may be helpful in maintaining muscle mass and preventing muscle wasting. Evidence also indicates that protein intake at the high end of recommended intakes is one factor that reduces the risk of bone mineral loss and bone fracture in the elderly. Dietary whey protein can also help bone status and help promote fat loss by serving as a good source of calcium. There is accumulating data demonstrating that specific components of whey protein may support health by serving as an antioxidant, lowering blood pressure, lowering cholesterol, enhancing immune function, and having anticarcinogenic properties.[4,34-36] Whey protein provides an unusual, even unique, combination of nutritional value and flexibility for food applications. This combination has great value for a population that struggles to meet protein requirements.

Table 2. Approximate Amino Acid Profile of Various Types of Commercially Available Protein (g/100 g protein)

Ingredient	Soy Protein Concentrate	Soy Protein Isolate	Egg Protein (Dried)	Milk Protein Isolate	Calcium Caseinate	Whey Protein Concentrate (80%)	Ion-Exchanged Whey Protein Isolate	Cross-Flow Micorfiltration Whey Protein Isolate	Whey Protein Hydrolysate
Alanine	4.60	4.30	5.77	3.50	3.00	4.82	5.60	5.60	5.20
Arginine*	7.90	7.60	5.43	3.50	3.70	3.18	3.00	1.70	3.00
Aspartic Acid	11.90	11.60	10.18	8.00	6.90	12.26	12.30	12.70	12.30
Cysteine/Cystine	1.40	1.30	2.59	0.60	0.40	2.28	1.90	2.50	2.90
Glutamic Acid	19.00	19.10	13.29	20.80	20.90	15.41	17.70	19.70	18.30
Glycine	4.60	4.20	3.49	1.90	1.80	2.00	1.90	2.00	2.30
Histidine*	2.80	2.60	2.26	2.70	2.90	2.41	2.00	1.80	1.90
Isoleucine[H]*	5.20	4.90	5.66	4.40	4.60	6.41	5.40	6.80	5.50
Leucine[H]*	8.50	8.20	8.41	10.30	9.10	11.60	13.50	10.90	14.20
Lysine*	6.90	6.30	6.80	8.10	7.70	9.83	10.90	9.50	10.20
Methionine*	1.50	1.30	3.44	3.30	2.90	2.35	3.50	3.10	2.40
Phenylalanine*	5.40	5.20	5.82	5.00	5.10	3.56	3.40	2.50	3.80
Proline	5.60	5.10	3.91	9.50	10.40	6.28	4.80	6.30	5.10
Serine	5.10	5.20	6.88	6.20	5.80	6.24	4.50	5.30	5.00
Threonine*	4.20	3.80	4.55	4.50	4.30	8.44	5.30	8.30	5.50
Tryptophan*	1.20	1.30	1.23	1.40	1.20	1.80	1.50	2.00	2.30
Tyrosine	4.00	3.80	3.91	5.20	5.50	3.26	3.90	3.10	3.90
Valine[H]*	5.40	5.00	6.37	5.70	5.70	6.09	5.40	6.40	5.90
Total BCAA[H]	19.10	18.10	20.45	20.40	19.40	24.10	24.30	24.10	25.60
Total EAA*	49.00	52.14	49.97	48.90	47.20	55.67	53.90	53.00	54.70

Adapted from Bucci LR and Unlu LM [3].
[H]Branched Chain Amino Acids (BCAA)
*Essential Amino Acids (EAA)

Table 3. Physiological Effects of Various Protein Fractions Found in Whey Protein

Protein Fraction	Biological Role or Function
β-lactoglobulin	β-lactoglobulin comprises about 50% of whey protein content. Although the specific biological role β-lactoglobulin is not known, β-lactoglobulin binds to minerals (e.g., zinc, calcium, etc), fat soluble vitamins (e.g., Vitamin A & E), and lipids and is therefore important for a number of physiological processes.[37,38] Contains a high concentration of BCAA.
α-lactalbumin	α-lactalbumin comprises about 25% of whey protein and has been reported to have anticancer,[47] antimicrobial effects,[37,39] and immuno-enhancing properties.[37,48] Research has also suggested that α-lactalbumin increased serotonin production in brain, improved mood, and decreased cortisol levels.[49]
Peptides	Whey derived peptides believed to reduce cholesterol,[50] blood pressure,[6,51,52] and protect against some forms of cancer.[53,54]
Albumin	About 5% of whey protein consists of bovine serum albumin (BSA). BSA is believed to have antioxidant[55] and antimutagenic properties.[56] Binds free fatty acids avidly; chelates pro-oxidant transition metals.
Immunoglobulins	Immunoglobulins (e.g., IgA, IgM, IgE, and IgG) support passive immune function. Although most of this research has been conducted on infants, new studies are now examining whether older adults may also benefit from increasing dietary intake of bovine immunoglobulins.
Lactoferrin	Lactoferrin is a protein that binds to iron and therefore has a number of potential applications.[29] Additionally, lactoferrin is believed to have anticancer,[57,58] antimicrobial,[34,59-61] antiviral,[4] and antibacterial,[34,60,61] and antioxidant[62] properties. Anti-inflammatory and immune modulation.
Lactoperoxidase	Lactoperoxidase is an enzyme that breaks down hydrogen peroxide and has antibacterial properties. Lactoperoxidase has been used as a preservative and in toothpaste to fight cavities. Lactoperoxidase has also been reported to have antioxidant[62] and immunoenhancing properties.[63]
Glycomacropeptides	Glycomacropeptides are believed to suppress appetite and have antiviral, anticancer, anti-platelet, antihypertensive, and immunomodulatory effects.[64-67] [64] Prevent dental caries. Almost devoid of phenylalanine; used in PKU patients.

WHEY PROTEIN AND ITS BENEFITS IN ELDERLY AND HEALTHCARE NUTRITION

Information courtesy of Dr. D. Breuillé and Dr. Z. Kratky
Nestlé Research Center

Adapted from a report by Dr. Kratky at the Health Claims for Whey Workshop, May 7, 2003, Tunisia.

Several factors affect the final nutritional value of a protein: its amino acid composition, its levels of hydrolysis, its digestibility, absorption issues, digestion rate, the presence of bioactive peptides in the protein and the existence of metabolic derangements in the individual.

Studies were conducted by Nestlé as part of the Clinical Nutrition and Performance Nutrition Program, which compared the digestion rate of whey and casein in elderly volunteers. These demonstrated that the protein digestion rate of whey was higher than that of casein.[1] In another study on nine healthy elderly volunteers, postprandial protein synthesis and balance was higher with whey than with casein.[2] The conclusion of these trials was that whey-based supplements induced higher protein synthesis and balance than casein-based ones.

Nestlé researchers designed, for patients with a compromised gastrointestinal function, a proprietary peptide-based diet product (Peptamen) for enteral nutrition which contained hydrolyzed whey proteins and medium chain triglycerides. Whey was selected as being rich in cysteine (precursor of glutathione and glutamine), rich in branch-chain amino acids (precursors of glutamine) and low in arginine (promotes glutamine synthesis). A number of hypotheses have been developed concerning the beneficial effect of glutamine in various clinical situations. Glutamine concentration is known to be depleted in catabolic states. Other important roles for glutamine include being an energy source for rapid turnover cells (immune cells, intestinal cells), and its ability to limit mucosal atrophy and to reinforce the gut barrier. Animal studies showed that weight gain and glutamine concentration in plasma and muscle, after starvation followed by refeeding, were superior when using the whey-based proprietary products than with soy-based control diets or simple amino acid mixtures.[3] According to these studies, whey proteins, although containing a relatively low glutamine level, were the most efficient to improve the glutamine status.

Whey proteins are known to be an excellent source of essential amino acids (45% of the protein), and are superior sources — compared to casein and soy — of cysteine, threonine and leucine. The requirements for these amino acids may be increased in case of stress and in the elderly. Cysteine, in particular, is the rate-limiting amino acid for glutathione synthesis, and it has a primary function in the defense of the body in case of stress. The dietary supply of cysteine has a beneficial effect on the glutathione status and on muscle protein synthesis in polytrauma patients.[4] Denutrition leads to impaired glutathione status. Glutathione concentration in blood and tissues is also negatively impacted in case of viral infection (HIV, hepatitis), burns, trauma, sepsis, surgery and chronic inflammatory diseases. Studies have shown that oral supplementation with whey protein increases plasma glutathione levels of HIV patients.[5]

It can be concluded, from these existing studies, that whey proteins seem to fit well the unique needs of the elderly, in particular in post-trauma recovery periods and for those affected by viral infections or chronic inflammatory diseases. Specific benefits include a rapid digestion rate, the inducement of high post-prandial protein synthesis and balance, the provision of essential amino acids, and a high content of cysteine that can support the maintenance or improvement of glutathione status.

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WHEY AND CARDIOVASCULAR HEALTH*

By Sharon Gerdes
S K Gerdes Consulting

and

Dr. W. James Harper, PhD
The Ohio State University

Edited by Dr. G. Miller, PhD
Senior Vice President, National Dairy Council

A growing body of scientific evidence reveals that U.S. whey contains various bioactive components that may have a positive effect on cardiovascular health. Certain bioactive peptides may protect against hypertension through angiotensin converting enzyme (ACE) inhibition and opioid-like activity. Bioactive whey peptides may also be involved in inhibiting platelet aggregation and lowering cholesterol levels. Other whey components such as calcium, magnesium, zinc, B-vitamins, and certain lipid fractions may also help reduce the overall risk of cardiovascular disease.

Food scientists generally favor whey proteins because of their high biological value, excellent functional properties and clean flavor profile. U.S. whey ingredients are used throughout the world in beverages, bars and other food systems. Newer whey ingredients include hydrolyzed whey proteins that contain high levels of bioactive peptides; and milk mineral complex, which is rich in calcium, phosphorus and other minerals. These two ingredients show particular promise as components of functional foods designed to improve cardiovascular health. Whey ingredients might also be used as components of other foods such as fermented or hyperimmune milk drinks, or products with increased levels of conjugated linoleic acid (CLA), to produce a new generation of dairy products designed to promote cardiovascular health.

Coronary heart disease is the leading cause of morbidity and mortality in western society. Heart disease is common in every "Westernized" country in the world, and as more countries adopt Western diets and lifestyles, the incidence of heart disease increases steadily worldwide.

Important risk factors for heart disease include smoking, hypertension, high blood cholesterol and triglyceride levels, diabetes and genetic disposition. For many years, low fat dairy foods have been recommended as part of a total diet to reduce the risk of cardiovascular disease. Recent research reveals that specific components of whey may also positively impact coronary health.

While the majority of research has involved laboratory and animal studies, further human trails are needed to substantiate the efficacy of whey peptides and other whey ingredients. U.S. whey ingredients are highly valued for their functional and nutritional properties; and the evidence of their cardiovascular benefit is expected to further enhance their popularity as components of regular and functional foods.

* Excerpt from a monograph titled: Bioactive Components of Whey and Cardiovascular Health. published by the U.S. Dairy Export Council. Document available at: **www.usdec.org** (see "publications").

BIOACTIVITY AND ANTI-AGING**

By Dr. C. J. Dillard
Department of Food Science and Technology, University of California, Davis

and

Dr. R. L. Walzem
Texas A & M University

and

Dr. J. B. German
Department of Food Science and Technology, University of California, Davis

Evidence continues to accumulate that whey contains a variety of nutrient factors that are capable of improving health and preventing disease. In particular, newer information in the areas of nutrient bioavailability, regulation of cellular growth and maturation, probiotics, prebiotics, toxin elimination and pathogenic virulence indicates that there is potential to produce healthful functional foods and pharmaceuticals to reduce both infectious and chronic diseases. These benefits are important to seniors nutrition.

Beyond the interaction with the gut and intestinal immune functions, more and more benefits are being tested that are logical predictions from the molecular actions at the level of the intestine, immune system and cellular biology. Of these beneficial effects of whey proteins have been reported in relation to inhibition of cancer cell growth adjuvant, as antihypercholesterolemia agents and as antiaging agents.

Maturation

The various tissues and cellular systems of mammals, including humans, undergo processes of maturation both early in life and throughout the life cycle. Examples include the development of self-non-self recognition by the immune system in infancy and tolerance to various antigens throughout life. The well-recognized interaction between whey components and the immune system is one of the most promising nutritional properties of whey. Particularly, in aging adults in whom immune senescence becomes a serious threat to an appropriate response to pathogens, the inclusion of maturation supporting factors in the diet would be beneficial. It is also attractive to speculate that many of the benefits of yogurt-like products on the immune system are the result of the positive interaction between beneficial probiotic bacteria and whey components consumed simultaneously with them.

Protection

The substantial body of knowledge emerging on the antimicrobial properties of whey proteins such as lactoferrin have brought this benefit of milk components even beyond the scientific community to general acceptance by a large lay audience. Although it is not the subject of this review, an apparent evolved benefit of milk has been to promote through a variety of effective means, a microfloral population with many protective properties. The value of whey components as prebiotics in stimulating a beneficial microflora is not as well established to date, yet this awareness is continuing to develop. The value of whey components in protection is a nutritional benefit that is directly transferable to adults in all life stages.

Elimination

The aggressive and rapid elimination of toxic substances and microorganisms is a largely overlooked benefit of protective nutrients, especially those in milk. The most obvious mechanism of action of toxin-binding glycoproteins and glycolipids in milk is to supply the same molecules to the digestive tract that are present on the surfaces of intestinal cells. By binding toxins in the gut contents, their elimination becomes a vivid example of simplicity in action. Gastrointestinal contents are propelled by the combination of fluid viscosity and peristalsis. The fact that whey components stimulate and regulate smooth muscle cell functions has become an area of intense interest as it has become clear that the decrease in gut motility is an important factor in the deterioration of optimal gastrointestinal functions during aging.

Excerpt from Chapter 6.3: Health Enhancing Properties of Whey Proteins and Whey Fractions, in Reference Manual for U.S. Whey and Lactose Products. Published by the U.S. Dairy Export Council. Document available at: **www.usdec.org (see "publications").

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