Fortifying Grain-Based Products with Whey Protein

L. DAVIS
Davisco Foods International Inc.
Eden Prairie, MN

With the increasing popularity of high-protein, low-carbohydrate diets have come the development of a variety of products that cater to people following these types of diet regimens. Grain-based products are traditionally higher in carbohydrates and, therefore, are not consumed or are consumed in much smaller amounts by people following these types of diets. However, grain-based products can also be rich sources of whole grains and dietary fiber, which are essential to a healthy, balanced diet. The dietary requirements of consumers following high-protein, low-carbohydrate diets is generating a market for protein-fortified grain-based products and creating new opportunities for food manufacturers. Additionally, research is being done that clearly demonstrates the nutritional health benefits of whey protein, making fortification of grain-based products with this protein an attractive option for manufacturers.

Whey protein, a high-quality protein source derived from milk, is a by-product of cheesemaking. Whey protein is a collective term for proteins from cow's milk that are soluble in the low-pH environment created during cheesemaking. The cheesemaking process liberates whey protein. Whey protein initially gained popularity in sports nutrition products as a source of high-quality protein and a rich source of the branched chain amino acids necessary for building muscle and lean body mass. Mainstream food products are beginning to take advantage of the nutritional benefits of whey protein, as well as its bland flavor, functionality, and health benefits.

Whey Protein Ingredients

In the past, liquid whey was considered a waste by-product of cheesemaking and, as such, was disposed of in fields, as well as other places. In an effort to reduce waste and eliminate environmentally harmful practices, manufacturers began using whey in various animal feeds and human foods as a liquid ingredient or in a dry powder form. Over the past 20 years much research has been conducted to develop new technologies for isolating and purifying the proteins contained in liquid whey and in studying the health benefits of whey protein.

Whey protein concentrates and isolates contain a conglomeration of proteins that have individual attributes, which when fractionated and isolated can lead to new, highly potent, nutritional advantages.

These proteins include β-lactoglobulin, α-lactalbumin, bovine serum albumin, immunoglobulins, glycomacropeptide, lactoferrin, lactoperoxidase, and proteose peptones. Today, whey protein is available to food manufacturers in various forms and purities, making it suitable for a variety of applications.

Whey Protein Concentrates. Whey protein concentrates have a protein content of 25–89% according to standards. These concentrates are manufactured using ultrafiltration technologies. The whey is filtered using polysulfone, semipermeable membranes and pressure to concentrate the protein based on molecular size. Using these technologies, the attributes of the proteins are preserved and nurtured throughout the process.

Whey Protein Isolates. Whey protein isolates are defined as having >90% protein on a dry weight basis. These products can be made using concentration (i.e., membrane filtration) or isolation (i.e., ion-exchange chromatography) methods. Isolates have higher purity than whey protein concentrates and exhibit certain advantages in nutrient density and functionality. In general, whey protein isolates processed using ion-exchange chromatography have higher purity than their counterparts processed using membrane filtration.

Hydrolyzed Whey Protein Ingredients. Hydrolyzed whey protein ingredients are also available as either whey protein concentrates or isolates. Enzymes are used to break peptide bonds between specific or random amino acids. The result is the generation of peptides or polypeptides with different sizes and characteristics. Hydrolyzed whey protein isolates or concentrates differ depending on enzyme selection, degree of hydrolysis, purity of raw material, and processing conditions.

Isolated and Purified Whey Protein. With advances in technology, it is now possible to isolate and purify the individual major proteins and subproteins found in whey. Whey protein components, such as β-lactoglobulin, α-lactalbumin, and glycomacropeptide, have been isolated, fractionated, and purified. These commercially available purified forms have unique nutritional attributes, as well as interesting functional properties. These properties are not attainable in traditional whey protein isolates because the bioactivity, nutritional properties, and functionality of these proteins and subproteins require high purity (i.e., >90% purity) to be potent enough to have the desired efficacy in humans.

Functional Properties of Whey Protein. In their native form, proteins from whey are 100% soluble. During processing, the environment around the proteins changes. These processing conditions (i.e., heat, pH, ionic strength, etc.) can cause the proteins to modify their conformation or shape, resulting in varying degrees of denaturation or modification. Denatured proteins behave differently than native-state proteins. Some of the differences are manifested in their ability to gel, bind water, thicken, foam, emulsify, form films, etc. Depending on the application, it is possible

Publication no. W-2003-1215-01F.

to exploit these functional properties by controlling the modification of the proteins in a "controlled denaturation." The properties that result from controlled denaturation can enhance the functional properties of whey protein in grain-based products, such as baked goods, particularly as they relate to rheology and flavor.

Health Benefits of Whey Protein

As mentioned earlier, whey protein is a high-quality, complete protein that delivers all the essential amino acids needed by the human body. In addition to providing protein, many other health benefits have been attributed to consumption of whey protein. Whey protein has been proven to have a positive effect in a number of areas, including immune support, cancer therapy, cardiovascular health, infant nutrition, and sports nutrition.

Immune System. One of the many encouraging aspects of whey protein nutrition is the enhancement and stimulation of the immune system. Many proteins and subproteins from whey play integral roles in modulation of the immune response. Modulation is very important in regulating immune responses in the body so they contribute to improving overall health without becoming excessive (i.e., allergic reactions). The sulfur-containing amino acids present in high levels within these proteins (in particular cysteine) enhance the production of glutathione, which is a very important natural antioxidant produced in the human body and part of an effective baseline immunity within the body. The immune system is one of the least understood and most important aspects of preventing and actively fighting disease in the body.

Cancer. Advancements in cancer prevention and disease-fighting therapies in humans are occurring regularly in research institutions around the world. Unfortunately, understanding has not progressed to the point where cancer can be prevented or effectively treated in many cases. In addition to the immune system contributions mentioned above, whey protein has been shown to reduce the number and size of various cancerous tumors in both animal and human studies. A study by Badger (4) at the Arkansas Children's Nutrition Center showed that whey protein-fed rats developed fewer and smaller breast cancer tumors than control rats.

Cardiovascular Health. Hypertension, or high blood pressure, affects approximately 50 million people in the United States and approximately 1 billion people worldwide (2). Specific peptides found in whey protein have been found to have bioactive properties. Many peptides have been identified in the literature as having angiotensin converting enzyme (ACE) inhibitory (antihypertensive) and opioid activity (1,3,5,6). ACE plays an important role in increasing blood pressure by converting angiotensin I to angiotensin II, which exhibits a strong vasoconstricting action that leads to hypertension.

A hydrolyzed whey protein isolate containing bioactive peptides (BioZate 1, Davisco Foods International) has been shown to lower blood pressure in both animal and human clinical studies. A clinical pilot study conducted at the University of Minnesota Hypertension and Cholesterol Research Clinic showed that this hydrolyzed isolate significantly reduced both systolic and diastolic blood pressure, as well as total and low-density lipoprotein cholesterol in nonmedicated, borderline hypertensives (7). The delivery system in the clinical study was a powdered protein beverage mix, but the bioactivity of this hydrolyzed whey protein isolate can be delivered in many different forms, including nutrition bars and a variety of bakery applications, including pancakes, brownies, cookies, etc.

Applications

Applications in which whey protein ingredients have been added successfully to grain-based products include extruded cereals, oatmeal products, breads, pancakes, pastas, tortillas, chips, crackers, brownies, cookies, cakes, etc. Achieving a protein content of 5–9 g per serving allows for a "good source of protein" nutrient content claim, while a protein content of ≥10 g per serving allows for an "excellent source of protein" nutrient content claim. It is possible to achieve these protein levels through the combination of whey protein with the protein found in grain-based ingredients. The bland flavor of whey protein is an added benefit in formulating protein-fortified grain-based products because it does not interfere with the overall flavor profile of the final product.

Conclusions

Whey protein ingredients are some of the most complete sources of proteins and essential amino acids available in nature that can be used for protein fortification of grain-based products. Whey protein ingredients can be added to almost any grain-based system to take advantage of their high protein content, essential amino acid content, specific preventative and targeted nutritional benefits, and functional properties. Fortification with whey protein will result in new grain-based food systems that take advantage of the health benefits associated with whey protein.

References

1. Abubakar, A., Saito, T., Kitazawa, H., Kawai, Y., and Itoh, T. Structural analysis of new antihypertensive peptides derived from cheese whey protein by proteinase K digestion. J. Dairy Sci. 81:3131, 1998.
2. Chobanian, A. V., Bakris, G. L., Black, H. R., Cushman, W. C., Green, L. A., Izzo, J. L., Jr., Jones, D. W., Materson, B. J., Oparil, S., Wright, J. T., Jr., Roccella, E. J., and National High Blood Pressure Education Program Coordinating Committee. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. JAMA 289: 2560, 2003.
3. FitzGerald, R. J., and Meisel, H. Lactokinins: Whey protein-derived ACE inhibitory peptides. Nahrung 43:165, 1999.
4. Hakkak, R., Dorourian, S., Shelnutt, S. R., and Badger, T. M. Diets containing whey proteins or soy protein isolate protect against 7,12-dimethylbenz(a)anthracene-induced mammary tumors in female rats. Cancer Epidemiol. Biomark. Prev. 9:113, 2000.
5. Mullaly, M. M., Meisel, H., and FitzGerald, R. J. Synthetic peptides corresponding to α-lactalbumin and β-lactoglobulin sequences with angiotensin-I-converting Enzyme inhibitory activity. Bio. Chem. Hoppe-Seyler 377:259, 1996.
6. Pihlanto-Leppala, A. Bioactive peptides derived from bovine whey proteins: Opioid and ACE inhibitory peptides. Trends Food Sci. Technol. 11:347, 2001.
7. Pins, J. J., and Keenan, J. M. The antihypertensive effects of a hydrolyzed whey protein supplement. Cardiovasc. Drugs Ther. 16 (Suppl. 1):68, 2002.

Laurie Davis

Laurie Davis is the applications manager at Davisco Foods International Inc., a manufacturer of dairy-based food ingredients, specifically whey protein. Davis, an expert in the chemistry and applications of whey protein in food systems, is responsible for application product development, project management, and technical relationships with customers at Davisco. Davis holds a B.S. degree in food science from the University of Minnesota. She is currently working on her M.S. degree in food science.