Executive Summary

- Formulating appealing high-protein beverages for the health-conscious consumer.
- Optimizing beverage flavor and protein fortification.
- The ins and outs of available protein ingredients.

Mixing Up High-Protein BEVERAGES

Photo: BioDiversified Crop Marketing, Inc.

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Just a few years ago, high-protein beverages were the domain of bodybuilders and athletes. Now, the market caters to teens and elders and everyone in between seeking the good nutrition protein offers. With additional fortification, high-protein beverages can fill in for a meal, plus protein has satiating qualities and helps build lean muscle.

Anyone who has worked with protein beverages knows there is more to product success than just upping the percent of protein in the formula. "Many of today's protein beverages have customized amino-acid profiles," says Ram Chaudhari, Ph.D., senior executive vice president, chief scientific officer, Fortitech, Schenectady, NY. In addition to dialing in a specific nutrient balance, the value of every potential ingredient should be measured and weighed against its economic and functional impact. "Processing time and temperatures, and the finished-product pH must be monitored closely, otherwise you could denature the protein, and product quality will not be acceptable due to separation or sedimentation," he says.

Beverage basics

For credibility, a drink must offer a minimum concentration of active components to ensure a measurable

benefit. "It is also easy to focus on active ingredients and overlook the importance of the underlying foundation properties of the drink," cautions Chaudhari. "Acidity, saltiness and sweetness should be carefully balanced to optimize a drink's taste and flavor profile. Despite the quest for functionality, the single greatest predictor of a new drink's success is taste, not its functional ingredients."

When identifying ingredients to be incorporated alongside proteins, it is also important to consider usage of multifunctional ingredients. "For example, sugar functions as a sweetener, osmotic-balancing agent and energy source," says Chaudhari. "Similarly, glycerol is a sweetener, energy source, osmotic balancing agent and muscle dehydration preventative. Phosphate salts contribute free phosphate molecules and isotonic balance, and buffer acid—important for microbial and color stability, and flavor release. Stabilizing compounds, such as acacia gum and carrageenan, may be beneficial to work as stabilizers in the finished product."

Beverages may be fortified with other nutrients. "Most of the concerns we see from our customers involve label claims that they can make on their final product," says Chaudhari. "This is where true nutritional science becomes a major factor." His company closely works with customers when developing a premix that will contain the right amount of nutrients to meet intended specifications of the final product. "Other concerns we get often are taste, texture and stability questions," he says. "Customers want to know if adding multiple nutrients will affect the product's color, flavor and shelf life. A custom premix can be made that doesn't affect any of those attributes. This is another major benefit of using a nutrient system."

Ultimately, the choice of protein is the underpinning of the drink. "Developers are looking for the best bang for their buck when using ingredients. In high-protein beverages, the protein will be used at considerable levels, so it's key to source highly functional proteins," says Grace Harris, manager, applications and new business, Hilmar Ingredients, Hilmar, CA. "Functionalities to consider include heat stability, emulsification properties, acid stability and clarity (if a clear beverage is being formulated). The optimum protein will provide as many of the functional benefits in the overall formula as possible. Developers will also need to consider the protein's nutritional benefits and whether those benefits can meet their needs." For proteins, that means looking at the amino-acid profile and/or protein efficiency ratio (PER), biological value (BV) and/or protein digestibility corrected amino acid score (PDCAAS).

Dairy-licious

When it comes to nutrition and function, whey proteins deliver. "They are an excellent source of high-quality nutrition, scoring in the top ranks for most measurements, including a PER of 3.2 and 'perfect' PDCAAS of 1.0," says Harris. A PDCAAS of 1.0 means the protein provides 100% of essential amino acids.

Whey proteins can be processed in a variety of different ways to produce distinct protein profiles. "This means beverage developers can target particular market segments by offering specific health benefits, such as satiety or post-exercise nutrient replenishment," says Starla Paulsen, applications department manager, Glanbia Nutritionals, Monroe, WI.

Today, beverage protein fortification commonly uses traditional whey proteins made during the cheesemaking process, which have more of the branched-chain amino acids (BCAAs) leucine, isoleucine and valine than most other protein sources, according to Matthew Pikosky, Ph.D., director of research transfer, Dairy Management Inc.™ (DMI), Rosemont, IL. This is important to note when delivering claims on high-protein beverages.

"BCAAs are unique compared to the other amino acids, in that they are almost exclusively taken up and utilized by skeletal muscle to promote muscle protein synthesis, and/or provide fuel for exercising muscles during endurance-type activities," says Pikosky. "Leucine, in particular, has been identified as a key nutrient signal in turning on protein synthesis, or the making of new muscle."

Whey proteins isolated directly from milk are new-generation dairy ingredients that hold great potential for beverages. Because these whey proteins have not been through the cheesemaking process where annatto, starter bacteria and rennet enzymes are added, "the end product is more consistent," says John Lucey, Ph.D., professor, Department of Food Science, University of Wisconsin–Madison, and researcher, Wisconsin Center for Dairy Research. "In addition, the process of fractionating whey proteins directly from milk could reduce the thermal-processing load, reducing denaturation,

preserving product solubility and potentially improving the bioactivity of whey proteins."

Milk-derived whey proteins also contain less than 1% fat, even when concentrated to as high as 80% protein. That accounts for their bland flavor, low turbidity in solution, foaming capability and stability during storage.

Depending on the composition, protein ingredients can be subject to oxidation. "Whey protein derived from milk has low susceptibility to oxidation during storage, because it is low in milkfat and phospholipid, as well as has less enzyme activity that comes from the starter cultures or rennet present in traditional cheese whey," notes Lucey. "Therefore, even after prolonged storage, its flavor tends to remain consistent."

Depending on how any whey protein is produced, it can provide enhanced functionality for heat stability, clarity and viscosity control. When formulating with whey ingredients, developers will need to fine-tune their stabilizing systems "to maintain stability through the thermal process system to maintain adequate shelf life," says Harris. "If clarity is required in an acidic-based beverage, a whey protein isolate would be the protein of choice. Developers will need to make sure minimal fats are used in the formula. They'll also need the right acidulant—one that will not affect the stability of the protein. Typically, combinations of acids are used to help maintain clarity, as well as modify flavor."

Ready-to-drink (RTD) beverages are more difficult to develop than mixes. "An RTD requires a carefully developed stabilizing system, selection of an appropriate protein with the best functionality, decision on the thermal processing parameters, and identification of the overall nutritional requirements warranting the use of proteins in the system," Harris explains. "For dry-powder beverage mixes, the main concerns will be dispersability of the ingredients, bulk density and flavor contributions. Instantized whey proteins are recommended for this particular application. Heat stability and clarity will have less impact in these types of formulas."

Scott Rayburn, beverage applications manager, Cargill Flavor Systems, Minneapolis notes: "Protein beverage mixes have the advantage of not being in an aqueous solution long term. Mixes provide better pH for taste, and protein agglomeration is greatly reduced for a better profile."

The readiness—and lack of stirring—of RTD beverages is an advantage. "However, with RTD beverages, key areas such as solubility, viscosity and pH become forefront considerations," Rayburn says. Control of pH "is essential and must be tested in each beverage to maximize solubility," he says.

Solubility is tied to the protein's isoelectric point—the pH in which the protein's positive and negative charges are equal. At this point, the protein is least stable, and it varies among whey protein fractions. Although the term "whey protein" is often used generically, there are several specific whey proteins. The most abundant,

beta-globulin and alpha-lactalbumin, have isoelectric points of 5.3 to 5.5 pH and 4.2 to 4.5 pH, respectively. As the pH of a beverage reaches the whey protein's isoelectric point, the beverage will have a creamier appearance. Manipulating the concentration of the specific whey protein fractions is one way that suppliers can meet specific solubility challenges, as well as control beverage clarity or opaqueness.

Because whey protein is very soluble at an acidic pH below 3.2 and completely disperses without cloudiness or chalkiness, "we can create clear, thin, high-protein beverages without using stabilizers," says Paulsen. "Alternatively, the customer may prefer a thick beverage for the meal-replacement market. We can advise them on the right formula to achieve optimum mouthfeel, flavor and nutritional benefits."

Rayburn explains that "solubility issues are affected by protein type, as well as the grade of protein. Long-term solubility and protein agglomeration issues are affected by pH, buffering and any thermal processing. The final product must be formulated to perform well in the lab, the manufacturing environment and all the way to customer. Viscosity issues are less a challenge than overall mouthfeel." He finds dairy products easier to work with from a flavor perspective, but more complicated from a processing standpoint.

In addition, the correct whey protein can also help "speed up production time through reduced foaming," says Paulsen.

Soy-trition

Like dairy proteins, soy protein is nutritionally complete, providing all the essential amino acids necessary to support growth and development. "Soy protein isolate has an amino-acid profile that is very complementary to dairy proteins, because some amino acids found in lower concentrations in the dairy proteins happen to be higher in soy protein isolate and vice versa," says Greg Paul, Ph.D., global director sports nutrition, The Solae Company, St. Louis. "Soy protein isolate also contains naturally occurring antioxidants not found in dairy proteins. Antioxidants have long been researched for their potential ability to reduce muscle soreness and muscle damage after unaccustomed exercise."

Paul maintains that multiple studies show soy protein isolate is just as effective as whey protein for building muscle. "This is not surprising, considering both are nutritionally complete proteins that are easily digestible," he says. "Branched-chain amino acids are important for muscle growth, but glutamine and arginine must also be considered. Soy protein isolate has about 30% more glutamine and 300% more arginine compared to whey. Glutamine and arginine are natural signals for growth hormone release, and thus, play an important role in building muscle. These amino acids are also essential for proper immune function, and arginine is well-known for its role in blood-flow regulation."

Combining proteins with different absorption rates, like soy protein isolate, whey and casein, can prolong delivery of absorbed amino acids to muscle, which is key to supporting muscle growth and recovery. Whey protein is rapidly absorbed. Casein, a milk protein, can take several hours to be digested. "Amino-acid concentrations in blood peak somewhat later following soy protein isolate ingestion compared to whey, but its digestion rate is quicker than casein," Paul says. "Ingesting a combination of the three proteins helps prolong the anabolic window, or the amount of time muscle growth is stimulated by the muscle uptake of amino acids coming from the ingested proteins."

Most isolated soy proteins currently available have an isoelectric point at around pH 4.5. "For a high-protein soy beverage, it is important that the product be in the pH range 6.8 to 7.2," Paul says. While is possible to use isolated soy proteins in beverages in acid beverages (pH 3.0 to 4.0), he cautions that the proteins might have to be stabilized with a hydrocolloid.

Rheological properties, especially viscosity, have a major impact on beverage mouthfeel and consumer acceptability. One new isolated soy protein provides benefits in high-protein beverages by maintaining acceptable viscosities at high protein contents, while at the same time providing flavor advantages. "Most beverages contain at least low levels of fat, so emulsification properties of the soy protein used are important," says David Wehby, science fellow in applications research, The Solae Company. "Soy proteins, when correctly hydrated, can act as excellent emulsifiers themselves. A homogenization

step is needed as part of the process to produce a stable emulsion with small and regular-sized oil droplets, and it also creates a thick layer of globular protein in the interfacial film that stabilizes the emulsion."

Beware of potential interactions from other ingredients in the formula. Carbohydrate selection is usually a function of required sweetness. However, "reducing sugars, such as fructose, may produce undesirable browning reactions and flavors through their interaction with the soy protein," says Welsby. "Low-molecular-weight emulsifiers also need to be chosen with care. They may actually displace protein from the interfacial film and result in lower emulsion stability. Minerals, especially divalent cations, react with soy proteins, producing agglomerates that can result in separation and product breakdown. If the beverage formula contains high levels of these cations, adequate chelation must be provided for good stability."

For clear high-protein beverages, Kevin Segal, Ph.D. food scientist, Burcon NutraScience Corporation, Vancouver, British Columbia, recommends a soy protein isolate product that is "ideal for use in acidic beverages. Unlike conventional soy protein isolates, this product is completely soluble at the pH range of acidic beverages and provides transparent solutions," he says. This opens the door for development of high-protein, low-pH waters or other clear beverages for the vegan market. It also works well in neutral beverages.

This soy protein isolate "is also heat-stable in acidic beverages, allowing thermal processing such as hot fill with no loss of clarity," Segal says. It doesn't require stabilizers to keep the protein dispersed or suspended, he says.

Alternatively, transparent, acidic high-protein beverages could be prepared using a blend of whey and this soy to take advantage of the nutritional and health benefits offered by each.

Segal describes the flavor of the soy protein isolate as bland, without the beany flavor typical of conventional soy protein isolates. However, like other protein ingredients, it may bind added flavor compounds and reduce the perceived flavor intensity, so beverage formulations must ensure delivery of the desired flavor impact.

Flavor in function

Adding any functional ingredients can impact flavor. Protein is no exception. "Generally speaking, high-protein beverage formulations tend to have an overpowering characteristic of one type or another," says Paulette Lanzoff, technical director, Synergy Flavors, Wauconda, IL. High-protein, dry drink mixes tend to have a bitter, chalky quality. The prevailing issue in RTD beverages is sourness caused by acidification. "For RTD beverages, we recommend liquid flavors with a solvent system that will not be compromised by the processing conditions," she says.

For dry drink mixes, spray-dried flavors will offer the shelf life and solubility needed. Lanzoff suggests a highly aromatic flavor to help improve the aroma of the powder in the package, improving the overall acceptability of the product. The key to flavoring protein beverages, she believes, is not so much the selection of the flavor type as it is the modification of those flavors for the specific protein. For example, for soy proteins with beany or green off notes, she says, "we might reduce the beany notes in a vanilla flavor that will be used in a soy protein beverage and let soy provide the beany character. For a whey protein where sulfur egg notes predominate, we may modify the vanilla flavor so the character of the protein works with the flavor to impart a more custard-like vanilla. We would modify a strawberry flavor for soy proteins by reducing the green, leafy notes, but for dairy proteins we would select a strawberry flavor with a creamy characteristic. Protein isolates are often astringent, so we may build some juicy notes into the flavor."

Flavor selection can address the harsh flavors that come from the protein or other ingredients in the base. "Use flavors that blend better with protein, because they have characteristics similar to the protein off notes such as cranberry, grape, pomegranate or blends of these," says Greg Mondro, senior flavor chemist, Cargill Flavor Systems. "Another approach is to use masking flavors and flavors that work well with maskers, such as vanilla or creamy flavors blended with sweet fruit flavors such as peach or banana. Finally, stay away from flavors that clash or accentuate off notes. For example you are not going to have a great-tasting watermelon protein shake."

Remember that every ingredient added to a beverage formulation will have some sort of interaction or consequence. "Creating a great-tasting, stable beverage is about matching and controlling those interactions," says Paulsen. "Vitamins and minerals are especially reactive,

but something as simple as the form of a flavor can cause a reaction that needs to be controlled."

More favors for flavor

Other ingredients in the formula, such as thickening agents, can interfere with flavor perception in high-protein drinks. "Key flavor components need to be boosted to break the threshold," says Lanzoff.

Sometimes, other functional ingredients in the formula add unwanted flavors. "Although most flavor companies tend to mask these notes by layering flavors, such as vanilla variants, on top of the product mix, we have seen more success in engineering a flavor to fit around the unusual characteristics," Lanzoff says. "For example, a functional ingredient with a sulfur note of its own can easily be fitted with a peach flavor, wherein sulfur has been reduced to compensate." In formulas containing nonnutritive sweeteners, a blend of several sweeteners can help provide consistent sweetness during consumption.

Processing methods almost always affect flavor. Although heat treatment can change the underlying flavor characteristics of high-protein products, the most-significant processing consideration may actually come from the source of the protein. For example, Lanzoff notes that whey proteins from grass-fed cows in Europe and New Zealand have a different post-process taste than whey proteins processed from American grain-fed cows.

When formulating high-protein beverages, consider all of the factors that might impact flavor, mouthfeel and appearance. Those are the primary drivers of product success, not merely the amount of protein listed on the label.

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