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ONLINE EXCLUSIVE: THE NEXT GENERATION OF DAIRY INGREDIENTS

November 29, 2012
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Dairy ingredients are among the most multifunctional ingredients in the food industry. Their unique protein, carbohydrate, fat and mineral composition contributes functional, as well as nutritional, benefits to foods. Developers value their versatility and functionality in a wide variety of food applications. Consumers reap the benefits in the taste, texture and nutrition of the foods they consume.

Decades of research have provided the science to develop the processes used to manufacture dairy ingredients today. The dairy industry now can manufacture ingredients with customized compositions to meet many of the functional, as well as the nutritional, requirements in food formulation. As consumers look for new products that meet their evolving tastes and nutritional needs, it poses a challenge to dairy researchers to develop new ingredients that can deliver benefits to the foods of the future.

Though dairy ingredients are have a natural ability to perform the functions of foaming, gelling, emulsification and other important characteristics in food, there is always the possibility to extend and optimize their capabilities. The Dairy Research Institute continues to support new and exciting dairy-ingredient research to maximize the capabilities of milk and whey-derived ingredients, and to increase opportunities for their use in foods and beverages.

Milk-ingredient research

Most of us are familiar with traditional milk ingredients, such as nonfat dry milk (NFDM), sodium and calcium caseinate, rennet and acid casein, and even newer ingredients, such as milk protein concentrate and milk protein isolate (MPC/MPI), micellar casein, and native whey or whey proteins derived directly from milk. The processes to make some of these ingredients are well-established, but others are new to the dairy industry. They all have one thing in common: their origins come from dairy research.

Ultrafiltration (UF) is used widely in the dairy industry, with its beginnings in whey processing. UF membranes with varying pore sizes separate milk and whey's larger-molecular-weight proteins and fats from their smaller-molecular-weight lactose and minerals. UF of skim milk combined with spray-drying produces MPC, which is commercially available in protein levels of 42% to 89%. These ingredients are most commonly used in process cheese, nutrition drinks and bars. While versatile, they have some limitations. They tend to decrease in solubility as their protein content increases and good solubility is key to providing functionality in foods. An MPC with poor solubility can result in a grainy or chalky texture and the protein can settle out in a nutrition drink. Research is underway to develop processing techniques to improve the solubility of higher-protein MPCs like MPC80 (80% protein). One approach is evaluating the impact of manipulating the mineral content on the solubility of MPC80.

For some applications, solubility or water-binding ability is not important. Sometimes developers need to add protein without adding a lot of functionality. Extrusion research on whey proteins has developed some unique ingredients for bars, snacks and even meat analogs. Extrusion research on MPC aims to develop a similar product for bars and snacks. Even more studies are in progress to develop milk-protein-based structures that will provide new forms to add milk protein to foods.

Some milk ingredients, like caseins and caseinates, have traditionally been produced only outside the United States, mainly for economic reasons. MPCs have only been produced in the United States for about 10 years. This has created a research opportunity to develop ingredients that can replace the functionality of caseins and caseinates, while being feasible for MPC manufacturers to produce domestically. One project uses carbon-dioxide injection to manufacture an MPC with functional properties similar to acid casein, an ingredient used in process cheese and imitation cheeses. Other research is examining the modification of MPC by the enzyme transglutaminase to replace rennet casein in process cheese. Another process being researched demineralizes milk prior to ultrafiltration to yield an MPC that performs like caseinate. Caseinates are used in coffee whiteners, process cheese and nutrition drinks.

Technologies to separate or fractionate individual milk proteins have been developed but are not widely used by the dairy industry. Though the dairy industry commonly uses UF, the process is not well-designed to separate and isolate individual milk proteins, because many of the proteins are similar in size. However, milk proteins are charged molecules, and their charge can change based on the pH conditions in their environment. Ion exchange separates individual proteins by charge. Research is underway on new technology that combines the capabilities of both UF and ion exchange to separate individual milk proteins. Charged UF membranes utilize a UF membrane with a charge covalently attached to it. The combined action of the membrane pore size, charge on the membrane and solution pH can selectively allow the proteins with a charge to be retained and those proteins with no charge to permeate the membrane.

Another filtration process used first in the dairy industry for whey processing is microfiltration (MF). MF also separates by molecular weight, but it has a different pore size than UF, providing the ability to separate types of milk proteins from each other. One process being researched separates casein from the whey proteins in milk, producing what is called micellar casein and native whey. Both ingredients have unique properties, but the native-whey ingredients have never gone through the cheese-making process, unlike traditional whey ingredients. An additional project takes a look at a wide-pore UF membrane to concentrate native whey into an α-lactalbumin-enriched whey protein concentrate and a β-lactoglobulin-enriched whey protein concentrate.

Whey ingredient research

With humble beginnings as a waste product, whey ingredients are now highly valued. Research has provided the basis to move whey ingredients up the value chain from fertilizer, fuel, feed and, ultimately, to food. Similar to milk-ingredient research, some whey-ingredient research is focused on improving the performance of existing ingredients to expand their use in foods, in addition to isolating individual proteins. For example, a new process to isolate glycomacropeptide and immunoglobulins from whey using magnetic nanotubes is being researched. Another area of focus has been on developing food ingredients from underutilized streams of whey processing. UF and MF are mainstay processes used to make whey into the whey protein concentrates (WPC) and whey protein isolates (WPI) we are familiar with today.

Some other coproducts of WPC and WPI manufacture have been further evaluated by researchers. Ultrafiltration of whey also produces permeate, which contains most of whey’s lactose and minerals. This permeate can either be dried or used to produce lactose. Lactose production results in some residual components from permeate; this is called delactose permeate (DLP and is typically sold as a liquid for animal feed. It is inherently difficult to dry, which makes it tough to commercialize as a dry dairy ingredient. Research has helped discover ways to dry DLP, and one of those ways is to combine DLP with another coproduct of WPI manufacture called pro-cream. Pro-cream is a generic term used by the whey industry to describe the product that is microfiltered from whey to make a WPI. Pro-cream contains whey protein (60% to 70%) and a high level of phospholipid (10 % to 20%). Pro-cream is another underutilized ingredient in food, but combining it with DLP makes both ingredients better-suited for food use. Application work using pro-cream/DLP blends has included soups, cakes, caramels and ice cream.

Lactose from whey is another established food ingredient, but research is helping to increase its value by developing processes to convert it into specialty food ingredients. One such process uses a twin-screw extruder, and another process uses nanofiltration and adsorption chromatography to produce galacto-oligosaccharides (GOS). GOS are used in foods for their prebiotic benefits. Lactose lauryl ester is another lactose-derived ingredient with antimicrobial properties and might give lactose a higher value and new use in food.

Improving heat stability of whey proteins

Whey proteins are among the most functional and nutritional food proteins available. Much research has focused on characterizing the abilities of whey proteins to foam, gel, emulsify, bind water and remain soluble, as compared with other proteins. The challenge is the ingredients must perform well and remain functional under any processing conditions that a particular food might require. At high enough concentrations, whey ingredients are able to denature and gel upon heating. This ability is beneficial in many applications, like thickeners for sauces, but a detriment to others, such as beverages. Improving whey proteins' heat stability for beverage applications is a focus of today's research, because beverages are a good way to add protein to the diet, and many beverages are high in carbohydrates and low in nutrient density. Beverages come in many forms: high acid, neutral pH, clear, cloudy and/or fortified with vitamins and minerals, so researchers are helping to improve the heat stability of whey proteins under all of these conditions. Combining whey proteins with other ingredients, such as chelating agents, and even using processes such as high-intensity ultrasound are under investigation to enhance their heat stability. One typical method to give whey proteins more heat stability in neutral-pH beverages is to combine them with a casein-based ingredient like MPC. One current project examines how different combinations of MPC and WPC80 affect the heat stability of whey proteins. Modifying the whey proteins' gelling properties through whey fermentation to produce exopolysaccharides should enhance their water-binding and gelling ability with the goal of replacing other nondairy-based ingredients.

Ice cream is another food that presents challenges when it comes to adding protein. It is traditionally high in fat and low in protein. However, adding protein will make a typical hard-pack ice cream too hard to scoop out of the container. A new research opportunity will evaluate the use of both milk and whey protein ingredients in ice cream and their ability to produce a fortified product that consumers will also love.

Many of these new and improved dairy ingredients are only made possible through dedicated, precompetitive dairy-ingredient research to drive functional and nutritional benefits into the foods of the future.

Bill Graves is senior vice president, product research, Dairy Research Institute. He is responsible for all aspects of product research, including developing a strategic plan for product research with input from producers and processors. He provides technical expertise and counsel in the areas of dairy product, ingredient and packaging technology, along with dairy product quality and safety. Graves has more than 31 years of industry experience in research development and quality while working at Kraft Foods Inc. He received his bachelor's degree in food science at Cornell University. In addition, he completed his master's degree in food science at Rutgers, received an MBA from New York University and holds five patents.
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