2017 Protein Trends & Technologies Seminar

Formulating with Proteins

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2017 Protein Trends & Technologies Summary

The world's love affair with protein seems unabated. On the nutrition front, mainstream media continues to post positive messages on this macronutrient, with negative news infrequent and with few, if any, new revelations. Additionally, weight management is a top health concern. Proteins are perceived to be a positive option over the two other choices of fat and most carbohydrates.

Global Food Forums®, Inc.'s 5th annual Protein Trends & Technologies Seminar, North America's largest conference dedicated to the protein ingredient market and technologies, was held May 23-24, 2017, in Itasca, Ill., USA. The Pre-conference program on May 23rd discussed factors impacting the protein ingredient marketplace for decision-makers involved in the protein ingredient market. The May 24th Technology Program provided insights for product developers formulating with proteins.

Presentations or/and adapted versions made available by speakers are online at www.GlobalFoodForums/2017-Protein-Seminar/Store. Our 2018 Protein Trends & Technologies Seminar will be held May 22-23, 2018, at the Westin Hotel, Itasca, Ill., USA. www.GlobalFoodForums.com/2018-protein-seminar

The second day of the 2017 Protein Trends & Technologies Technical Program: Formulating with Proteins (which attendees could register for separately) targeted the information needs of those involved in the formulation of food, beverages and nutritional products. The event is also structured to allow networking among participants during breaks.

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The Global Food Forums Story

Welcome! We hope you enjoy and gain useful information from this, our 5th Protein Trends & Technologies Seminar Post-conference Summary. We are also celebrating our 5th anniversary as a corporation. When we launched the company in 2012, our vision was to develop a family of in-person, niche product development conferences for the food, beverage and nutritional products industries.

Each of our events, which includes the Clean Label Conference and Sweetener Systems Conference, is tied to a significant, long-term consumer and industry trends in which applied food science plays a crucial role. The technology-based programs are designed to provide R&D and other food scientists with practical and impartial formulation advice, along with consumer trend insights, emerging ingredients, regulatory updates and other factors impacting product formulations.

With food technologists as our core customers, all our company decisions are guided by how they will impact this community's event experience. To date, our events have drawn over 2,400 attendees, from bench-level food scientists to VP/directors of R&D, as well as those interested in interacting with this technologist community to better understand their needs and challenges.

We hope you'll attend some of our future events. We'll work hard to make them your best conference experiences ever!

PROTEIN TRENDS & TECHNOLOGIES SEMINAR

Warm regards,
Peter Havens &
Claudia O'Donnell
Co-owners, Global Food Forums, Inc.

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Body in Tune: How Consumer Demand for Healthier Food Impacts Protein Use in Foods & Beverages

Consumers are bringing nutrient-dense foods into their diets based on what they think will make them healthier. Kara Nielsen, Innova Market Insights, sees protein as a driving force in these product purchases. This is reflected in launches tracked from 2015-2016.

Growth of the protein market is led by sports nutrition. Protein fits into the notion of an active lifestyle. Formats and positioning are expanding, with the highest increase in sports bars (17%), sports powders (12%) and ready-to-drink categories (11%), as people look for more convenience and accessibility.

Specificity is also in demand. "We now have targeted products that focus on every moment and every bodily need," observed Nielsen. This includes pre-workout, which concentrates on energy and muscle-building; intra-workout for a boost to finish; and finally, the recovery side. Different protein ingredients are being marketed as key to each one of these stages.

With more people participating in sporty activities, expansion is targeting more consumer segments. Niche products are positioned to attract consumers with an active lifestyle, or they may be designed for a certain demographic, such as sex or age group. Positioning is also spreading beyond athletic categories.

"Sports nutrition is becoming more normalized," she continued, with 17% more product launches with a snacking claim, and in innovative formats and culinary flavors. The category is migrating into more mainstream foods formats, such as nut butters, bagels and waffles. Protein-enriched snacks are ideally positioned, because they often have other healthful benefits that are less common in other snacks. Additional health claims may include gluten-free, high-fiber or low-fat.

"The protein claim has moved out quickly over a number of years into every aisle of the grocery store," Nielsen said. Dairy is experiencing the largest growth of products featuring sport-related claims (up 46% in 2016 vs. 2015). Ready meals saw a 32% increase with the movement of protein pulses into pasta and other products with reduced carbohydrates. Cereal products rose 24%.

Specialization continues with products targeted for seniors or children; for on-the-go breakfast or lunch; and for weight management and satiety. Yet protein claims also have broad appeal as part of an everyday lifestyle. Product labels may boast protein for health and convenience. Some products are directed to certain times of the day—from breakfast to fuel the morning to a mid-afternoon energy boost.

Protein-rich ingredients also have a place in indulgent treats. A Mars bar that is fortified with 19g protein may be a guilt-free choice over an ordinary Mars bar. Similarly, high-protein frozen yogurt or chocolate pudding may be perceived as a healthier option.

Consumers not only want to know the amount of protein; they are also paying more attention to the source of protein. They are looking for identification of the protein and to understand the contents of a protein blend.

Nielsen foresees more formulations with premium ingredients and deeper interest in amino acids, as the sports nutrition category evolves. Continued expansion into mainstream aisles will bring more food-like products in convenient formats targeted for consumer segments.

For consumers who seek to get their bodies in tune with personalized protein, she recommends enhancing products with real food

Dairy-based protein continues to be the strongest and fastest growing ingredient in sports nutrition, foods for babies and toddlers, and cereals. Plant proteins are highest in the cereal category but low in the sports nutrition category.

Dairy and Plant Proteins Divided Among Food Categories

Dairy big in sports nutrition, baby & toddlers

% of products with a protein claim tracked with dairy-based proteins (global, 2016)

Dairy-based protein	
Sports nutrition	78.3%
Baby & Toddlers	43.4%
Cereals	24.4%
Dairy	14.8%
Ready meals	10.1%

Plant stronger in everyday food

% of products with a protein claim tracked with plant-based proteins (global, 2016)

Plant-based protein	
Cereals	39.8%
Meat, Fish & Eggs	30.5%
Bakery	28.7%
Sports nutrition	24.3%
Ready meals	14.2%

SOURCE: KARA NIELSEN, INNOVA MARKET INSIGHTS; 2017 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

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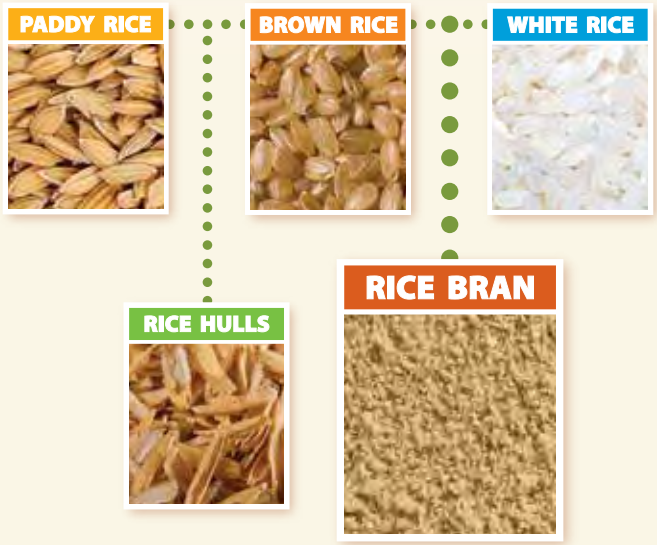

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ingredients. "Plant-based protein will continue to grow. It's part of our ethos right now in thinking, whether it's environmental (animal welfare), or health and nutrition (reducing cholesterol)." There are a lot of different reasons for choosing plant-based products. She believes catering to that need is important.

With protein claims increasingly driving activity across categories, one wonders when the trend might stall. "As someone who talks about trends, I keep thinking we've hit 'peak protein.' It doesn't seem like we're quite there," Nielsen said.

"Body in Tune: How Consumer Demand for Healthier Food Impacts Protein Use in Foods & Beverages," Kara Nielsen, Innova Market Insights, Netherlands, kara@innovami.com

Proteins for Health: Issues, Updates and Opportunities

University of Minnesota nutrition and food science Professor Joanne Slavin addressed the comparative qualities of plant and animal proteins by highlighting some stark implications for product developers and vegans.

"The most important macronutrient that we have in our diet is protein," she began. "In the end, fats and carbohydrates are just calories. Proteins, however, are comprised of 20 amino acids, nine of which cannot be manufactured by a healthy adult body and are, therefore, essential nutrients."

With protein, therefore, it isn't just a question of quantity, but also quality and availability. This is where Slavin anticipates challenges on the food and beverage horizon.

So…what do proteins do? They provide the building blocks for tissues, balance body fluids, control acidity, are integral to the immune function, produce hormones and enzymes, manage gluconeogenesis, deliver energy and signal satiety. "Whereas I can survive for a long time without most nutrients, the only two nutrients that I absolutely need in order to survive are water and protein," Slavin said.

"We can easily calculate how much protein people need," she added. "We know that protein needs increase during periods of growth, pregnancy and lactation. We also know that protein requirements begin to decrease after age 25."

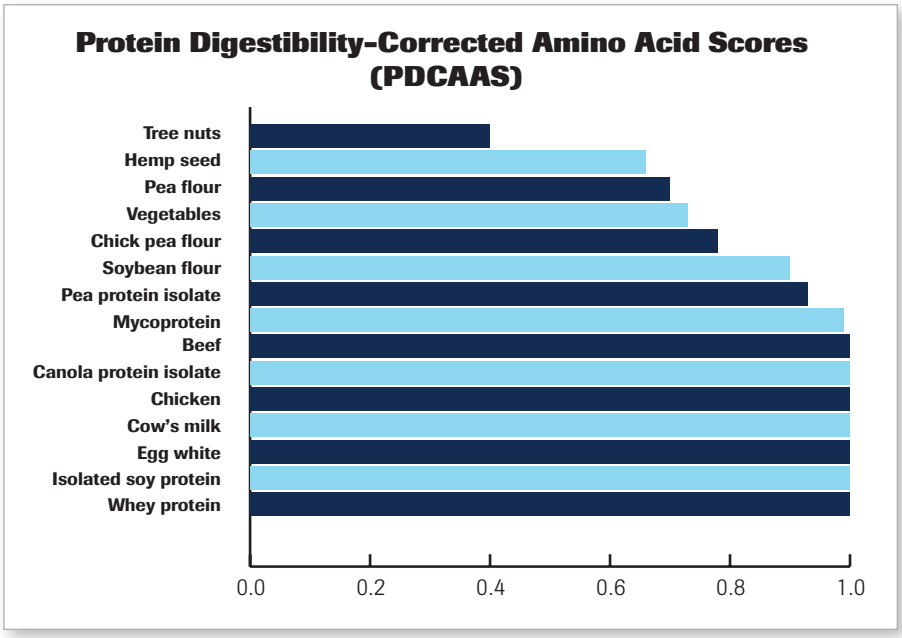
"The Acceptable Macronutrient Distribution Range (AMDR) for protein intake is 10-35% of calories," continued Slavin. Given that the

As people switch from animal to plant protein, there may be an increasing number of consumers, especially adolescent females, on low-quantity, low-quality protein diets.

Daily Value for protein is generally constant for individuals, reduced-calorie diets increase the required proportion of protein and vice versa. And, unless one has a kidney malfunction, "there is no upper limit for protein consumption, other than cost."

However, individual protein intake requirements depend heavily on protein composition: A protein low in essential amino acids

Percent Daily Values (%DV) on food and beverage packaging require a PDCAAS value of 1.0 if a protein claim will be made. However, unless highly processed, plant proteins contribute lower quantity and availability of essential amino acid values to diets than do animal proteins.



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JUNE 2013: Oryzatein® rice protein shown equal to whey at building muscle mass, gaining strength and helping with exercise recovery (*Nutrition Journal*)

NOV 2014: Muscle-building Leucine in Oryzatein rice protein shown to absorb 30% faster than leucine from whey protein (*Journal of Nutrition and Health Sciences*)

Coming SEPT 2017: Newest findings on Oryzatein vs. whey protein's impact on body composition of MMA fighters

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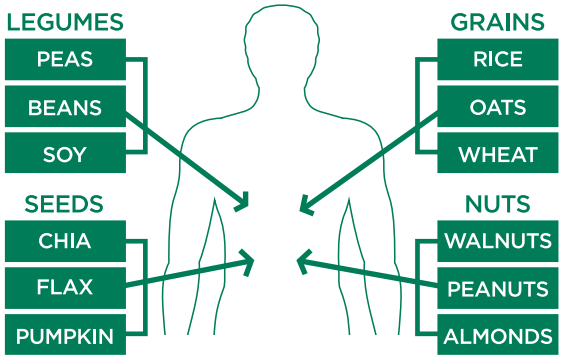

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necessitates a higher level of intake in order to fulfill the body's essential amino acid demand. Whereas animal proteins (eggs, milk, meat, seafood) reflect the perfect amino acid balance for humans, plant proteins do not. In addition, plant proteins are not as readily available nutritionally.

So, how to determine proteins? The FDA requires use of the Protein Digestibility-Corrected Amino Acid Score (PDCAAS) analysis for products other than for infants. It is, however, expensive and currently requires animal sacrifice (a "no-no" for many consumers).

"The only measure of protein efficiency allowed on a product label is the % Daily Value (%DV), but you must have a PDCAAS value of 1.0 before you can list your product's %DV for protein," stressed Slavin. This is difficult to achieve using plant proteins.

When humans lack the essential amino acids whereby to build new protein, our bodies break down existing proteins (e.g., muscle) in order to construct the "more important" proteins, explained Slavin. Consequently, a diet consisting of an adequate intake of protein can still be deficient in essential amino acids, leading to tissue breakdown.

"When people switch from animal to plant protein, it becomes more challenging," cautions Slavin. "I think that we are going to see increasing numbers of consumers on both low-quantity, low-quality protein diets, especially among adolescent females." Vegans take note!

The PDCASS value of plant proteins can be improved through blending and/or refining. Soy protein isolates have a PDCAAS value close to 1.0, "but only because ingredient manufacturers manufacture them that way. The only way to improve plant protein quality is by processing it…which goes against current consumer food trends favoring minimally processed whole foods."

To conclude, even though total or average protein intakes may seem adequate, protein quality and availability must also be factored into food choices. Protein is an essential nutrient, and reduced-calorie diets, though appropriate, must necessarily contain a higher proportion of protein in order to provide essential amino acids. As consumers move from away from animal proteins toward plant proteins, they should consider how protein quantity, quality and availability affect their nutritional status.

"Eventually, consumers will discover these linkages, and they may feel misled; hopefully, it will also force the FDA to revisit its protein labeling rule requiring a PDCAAS level of 1.0 before protein %DV can be listed on packages," she said. This will help clarify how good a source of protein the product actually is.

"Proteins for Health: Issues, Updates and Opportunities," Joanne Slavin, Ph.D., University of Minnesota Dept. of Food Science and Nutrition, jslavin@umn.edu

Protein and Amino Acid Analysis in Relation to Nutrition Labeling and Protein Quality

Protein serves structural, functional, physiological and metabolic roles in the body. The quality of dietary protein is largely determined by its amount of indispensable (essential) amino acids. Of the 20 amino acids present in protein, nine are indispensable and must be supplied by the diet.

Whey proteins are good sources of branched-chain amino acids, which are important for muscle synthesis. Cereals and grains are usually deficient in lysine; however, a mixture of pulses and grains can create a complete protein. Collagen lacks tryptophan and so is not a good-quality protein.

"Additional nutrients present in the protein food can make it more or less valuable in the diet. Animal foods often contain saturated fat and cholesterol, whereas plant foods are rich in dietary fiber and phytonutrients," said Sneh Bhandari, Ph.D., Merieux NutriSciences, in his presentation titled "Protein and Amino Acid Analysis in Relation to Nutrition Labeling and Protein Quality."

In the U.S., Protein Efficiency Ratio (PER) is the required method of calculating protein quality in foods for infants one year of age and younger, and PDCAAS is used for other foods. Canada recognizes PER as the preferred method but allows PDCAAs when PER is not available.

Bhandari explained that the Kjeldahl method of protein analysis is based on total nitrogen content and has been widely used and often referred to as crude protein. Originally, all proteins were

Protein Quality—DIAAS vs. PDCAAS

1. **DIAAS uses non-truncated AA scores for food ingredients. PDCAAS values >1, but truncates to 1.**
2. **DIAAS uses ileal AA digestibility value for each individual AA. PDCAAS uses fecal rather than ileal estimates of protein digestibility.**
3. **FDA recognizes DIAAS importance in evaluating protein quality when true ileal AA digestibility data are used.**
4. **However, FDA declined to replace the PDCAAS with DIAAS in the final rule (2016) due to "insufficient data to implement," among other reasons.**

SOURCE: SNEH BHANDARI, SILLIKER /MERIEUX NUTRISCIENCES; 2017 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

The DIAAS method corrects some PDCAAS issues but, for now, the FDA is not replacing PDCAAS with DIAAS.

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estimated to contain 16% nitrogen, and protein was calculated by multiplying the nitrogen value by 6.25. However, in 1941, factors ranging from 5.3-6.38 were established for specific food matrices. The FAO allows the conversion factor of 6.25 to be used for all foods, but the FDA requires AOAC-approved methods using specific conversion factors to be used when calculating PDCAAS. Non-protein nitrogen, which often exists as soluble nitrogen, must be deducted from crude protein values to calculate true protein.

Another common protein analysis is the Combustion/Dumas method, which measures oxides resulting from nitrogen combustion. Other less common methods use reflectance or transmission NIR.

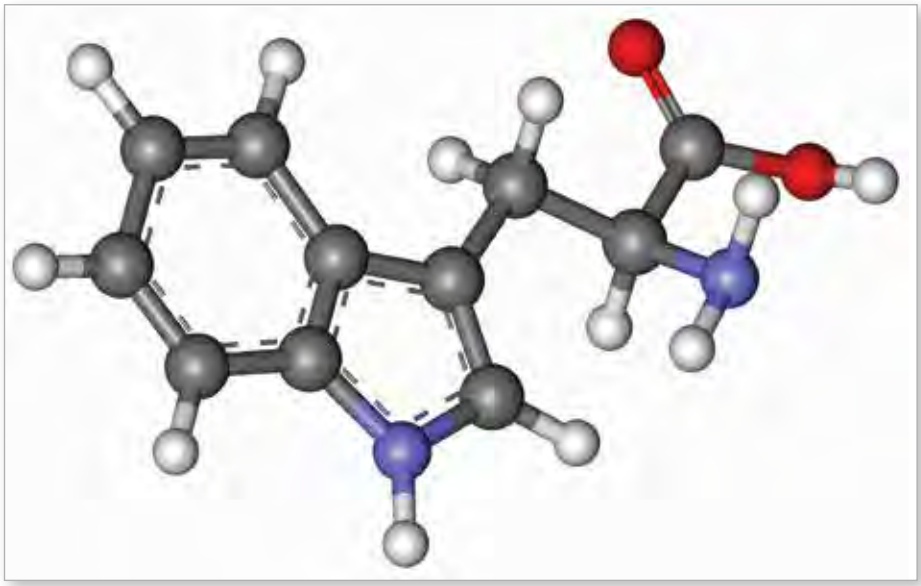
To analyze individual amino acids, the protein is hydrolyzed in 6M HCL for 18-24 hours at 110° C. Some amino acids are readily oxidized or damaged by acid hydrolysis. For example, tryptophan can be almost completely lost by acid hydrolysis, so an alkaline hydrolysis is performed instead. The sulphur-containing amino acids methionine and cystine degrade during acid hydrolysis and are protected by prior performic acid oxidation. Individual amino acids are commonly separated by ion-exchange chromatography, followed by post-column derivatization. Tryptophan can be analyzed by ion-exchange or reverse-phase HPLC methods.

In 1993, the FDA adopted PDCAAS as the official method to determine protein quality, Bhandari noted. The first step is to analyze crude protein and essential amino acid concentrations. Next, the amino acids' values must be scored against a reference pattern. The value for the limiting or lowest essential amino acid is the Amino Acid Score (AAS). The second step is to determine Protein Digestibility (PD). Human values are ideal, but rat values are often used. Finally, AAS is multiplied by PD, and values over 1.0 are rounded down to 1.0 (that is, when AAS is multiplied by PD and, if the resulting PDCAAS value is 1.05 or 1.8, it is rounded down to only 1.0).

There are several issues with the PDCAAS method, including the fact that fecal digestibility values are less accurate than ileal digestibility values. The Digestible Indispensable Amino Acid Score (DIAAS) method was recommended by FAO/WHO in 2013 to address these issues. The FDA agrees that DIAAS is a better method, but it declined to replace PDCAAS as the method for calculating nutrition labels in the 2016 final rule, because there was insufficient data to implement DIAAS. There are additional guidelines for reporting protein values on the Nutrition Facts panel.

Consumers continue to demand healthy quality protein. Accurate analysis of protein content will enable food manufacturers to make appropriate protein claims, Bhandari concluded.

"Protein and Amino Acid Analysis in Relation to Nutrition Labeling and Protein Quality," Sneh Bhandari, Ph.D., Merieux NutriSciences, sneh.bhandari@mxns.com



To analyze individual amino acids, protein is hydrolyzed in hydrochloric acid. Certain amino acids, such as tryptophan, are readily damaged by acid hydrolysis, so an alkaline hydrolysis is used.

Disruptive Ingredient Technologies: Characterizing Plant Proteins to Predict Optimal Food Matrix Use

Both wet- or dry-process pathways are used to industrially concentrate and purify ("refine") proteins to desired-quality parameters. The ideal is to provide the highest degree of purity and quality for the lowest possible cost. The tradeoff is that the purer and more undenatured a protein, the more expensive it is.

Denis Chéreau, Ph.D., CEO of IMPROVE SAS (Dury, France), reviewed emergent technologies that promise to significantly improve the purity, quality and economics of protein processing. IMPROVE SAS is a private R&D laboratory focused on food, feed, cosmetic and agro-material technologies.

"There are four key elements whereby to characterize proteins," said Chéreau, "nutritional value, functional properties, organoleptic quality, and labeling and health-claims compliance."

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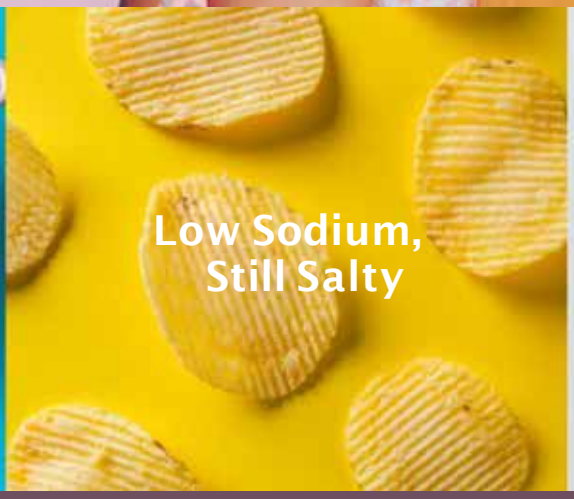

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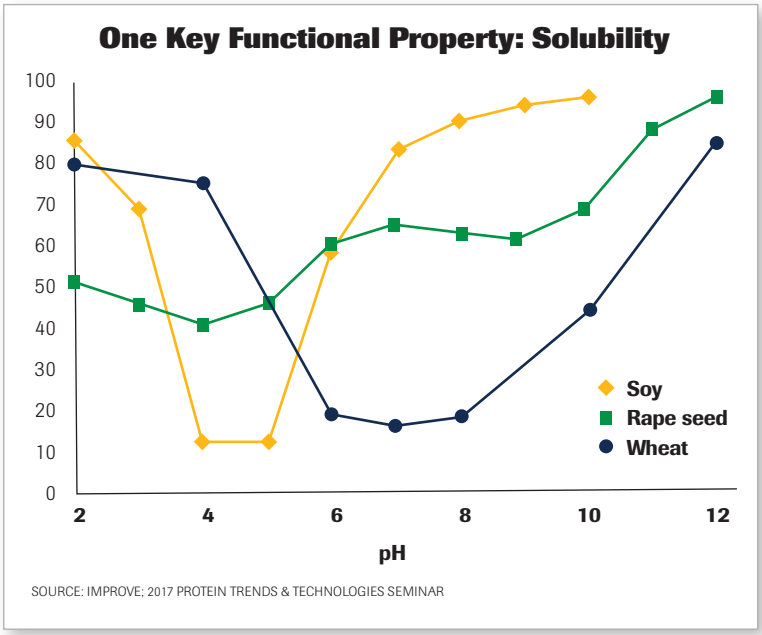

Nutritional value, functional properties, organoleptic quality, and labeling and health-claims compliance are the four key elements by which to characterize proteins. For example, solubility is an important functional property.

interfacial properties of native protein structures. Organoleptic properties rely on the matrix surrounding the protein and the raw material. Health claims and labeling compliance provide the interface whereby a protein meets consumer expectations and stays aligned with regulation.

In today's consumer market, "one has to consider protein allergenicity, anti-nutritional factors, peptide bioactivity, clean label perceptions, GMO status, 'organic' compliance, plant origin and protein purity," said Chéreau. All of these factors enter into processing considerations.

Chéreau catalogued some potentially "disruptive" technologies that promise to further enhance protein quality, consumer expectations and processing efficiencies. Some examples:

Dry refining. An advantage to dry processing is its compatibility with clean and organic labeling expectations, explained Chéreau. "It also helps to preserve a protein's native nutritional value and functional properties." Milling techniques optimized to yield ultra-fine seed flours, when combined with high-speed air classification, yield high-protein fractions. "Using an air classifier at 16,000rpm, we have been able to yield faba bean fractions with up to 70% purity," said Chéreau. There is a trade-off, however, between purity and yield. One promising method being investigated to enhance yield is to apply a "coronal discharge" to the flour and then separate the high-protein fractions based on their surface electrical charges.

Wet refining. Ultra-fine, milled dry plant-protein fractions can be further solubilized and purified through heat coagulation, isoelectric precipitation or membrane filtration. Efficient protein solubilization begins with very fine-milled particles. "We have been able to achieve close to 100% protein solubility in faba beans at pH 9-10, using 300 micrometer (micron)-sized particles, with 88.3% extraction efficiency," said Chéreau. The structures of the dry particles are also important. Each technique can yield protein isolates in the 80-92% concentration range with 70% yields. However, both heat coagulation and isoelectric precipitation can yield protein denaturation or organoleptic shortcomings, while conventional membrane filtration remains expensive.

Chéreau reviewed a number of "disruptive" technologies that could enhance the economic efficiencies of these processes. A few examples:

Forward osmosis uses semi-permeable membranes and a proprietary draw solution comprised of a "food-grade GRAS liquid" that can "easily be regenerated at very low cost." The operating temperatures for this step are between 10-50˚C, optimizing protein integrity. However, work is still underway to identify membranes able to operate at the pH 9-10 range for optimum solubilization. "The process requires very little energy; is easy to scale-up; and integrates easily into existing processing lines," said Chéreau.

Dynamic cross-flow filtration uses rotating ceramic disks to generate turbulent flow across membranes, resulting in significant energy savings… "as much as five times less than conventional systems," claimed Chéreau. "This system works well with high-viscosity fluids." The researchers are still working to resolve issues with high-viscosity by-product stream utilizations.

Electrostatic spray-drying shows promise for highly sensitive proteins, such as egg or milk proteins. The process electrically charges solvent particles, causing them to migrate to the exterior of the particles in a nitrogen environment, yielding enhanced drying efficiencies while minimizing energy costs. Drying temperatures for this process are 80˚C vs. 180˚C for more conventional spray-drying.

In sum, the presentation offered an encouraging and creative view of how next-generation, "disruptive" protein technologies could be mixed and matched to enhance quality and functionality with significant cost-savings.

"Disruptive Ingredient Technologies: Characterizing Plant Proteins to Predict Optimal Food Matrix Use," Denis Chéreau Ph.D., General Manager, IMPROVE SAS, denis.chereau@improve-innov.com

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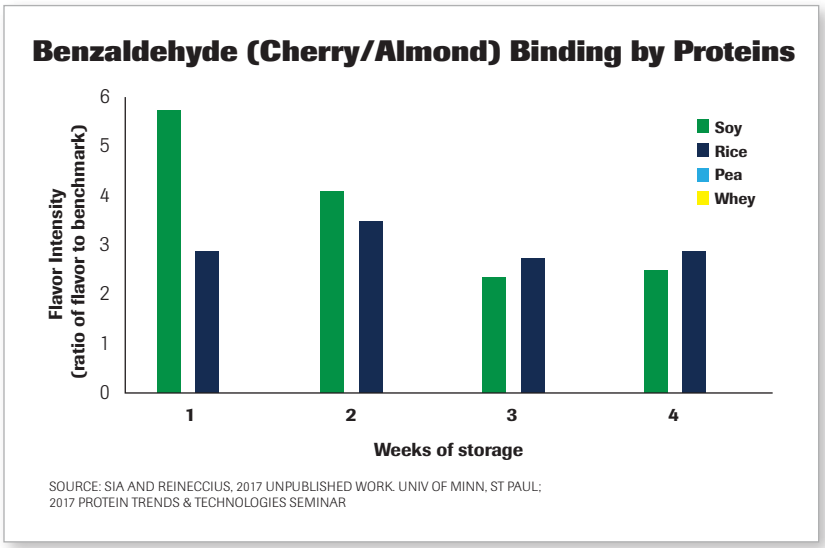
Protein Flavoring Problems: The Whys, Wherefores & Possible Ways Out

From a food or beverage product developer's point of view, does it make more sense to match the flavor to the protein or the protein to the flavor? This is only one of the questions addressed by renowned University of Minnesota flavor expert, Gary Reineccius, Ph.D., during his discourse on the art and science of flavor.

"Flavor" is a holistic response to chemical stimuli contributed by specific combinations of selected and highly reactive aroma chemicals (ca.11,300 have been identified in nature); non-volatile tastants (salty, sweet, sour, bitter, *umami*); and chemesthetic signals (e.g., heat of peppers and cooling of menthol). These combined chemical stimuli provide a pattern of signals to the brain that then are perceived as flavor.



Different proteins bond with different flavors differently. In this experiment, whey and soy quickly stripped volatile benzaldehyde (cherry or almond flavor) molecules from model protein bar system stored at very high temperatures. Thus no levels are shown in the graph above. Equivalent concentrations of rice or pea proteins allowed for better retention of this flavor, in this one case.

This same constellation of sensory signals must be rigorously managed throughout a food's manufacturing, storage, handling and preparation processes to ensure that, in the end, "the balance of a product's sensory inputs meets our expectations," said Reineccius.

Proteins in food are very reactive systems, he continued. Proteins can trap flavors in multiple ways through hydrophobic, hydrophilic or ionic reactions; or through covalent bonding with amino acid side chains to prevent their volatilization and sensory detection in the nose and mouth.

Reineccius proceeded to catalog some of the reaction pathways whereby protein-flavor interactions impact product quality. For example, the oxidative decomposition of residual phospholipids resulting in grassy, beany flavor-notes in soy and other legumes is well-known. Phospholipids are especially difficult to separate from legume proteins during processing, but he noted that the University of Wisconsin had recently been granted a patent on the use of cyclodextrins to strip phospholipids from plant protein streams. Heat and oxidation create their own sensory off-notes for animal proteins, such as in Maillard browning reactions in milk proteins during storage.

So, what are good strategies for dealing with the challenges of protein-flavor binding or off-flavor development? Reineccius counseled a methodical approach. The first step is to identify the off-flavor notes. Next, try to link the identified off-flavors to specific processing steps. Ask oneself if there are practical fixes to the process, storage and/or handling conditions responsible for Maillard browning reactions, oxidation or protein hydrolysis.

If the creation of off-flavor compounds is unavoidable, can the solubility or volatility properties of the identified off-flavor compounds be used to remove them (e.g., solvent extraction, adsorption or heat-stripping)? "You don't want to have to design a flavor system around the off-flavor notes, if you can avoid it," said Reineccius. He was highly skeptical of flavor-masking agents. "There has been some progress with this approach for bitterness, but I have yet to see success in truly masking off-odors."

Another approach is to select proteins based on their flavor reactivity. Different proteins absorb/chemically react with specific flavor compounds at different rates. Thus, there may be an opportunity to pair specific flavors with certain proteins.

"Often, one flavor compound characterizes, is absolutely key, to a product's flavor profile (additional components round out or complete the flavor profile)," said Reineccius. Benzaldehyde, for example: "When tart, we perceive benzaldehyde as cherry; if not tart, it's almond." He described how one of his students used protein bars—fortified with whey, soy, pea and rice protein and stored at 45°C—to document how benzaldehyde binding was significantly greater for pea and whey proteins than it was for rice or soy proteins. Hence, one might opt for rice instead of whey protein in cherry- or almond-flavored products. (See chart "Benzaldehyde (Cherry/Almond) Binding by Proteins.")

"Here is my advice, said Reineccius: "When working on a project that involves protein and flavor interactions, work

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closely with people that have experience in this area, because it (flavor chemistry) is still an art. Otherwise, if we depend only on science to tell us what we need to know, we are in trouble. We have much to learn yet."

"Protein Flavoring Problems: The Whys, Wherefores & Possible Ways Out," Gary Reineccius, Ph.D., Professor and Past Department Head, Dept. of Food Science & Nutrition, University of Minnesota, greinecc@umn.edu

Smart Protein Blending

Food formulators can choose from a wide range of proteins from plant and animal sources, as well as novel sources—including algae, insects and hydrolysates. Both consumers and government agencies are demanding greater use of plant proteins, but blending different proteins can be challenging. "Smart blending of plant and animal proteins enables industry to optimize nutritional value, sustainability and price," said Laurice Pouvreau, Ph.D., Senior Scientist Protein Functionality, NIZO, in her presentation.

Protein blends can come from the same source (i.e., dairy casein and whey); from a mixture of proteins (i.e., whey and soy); or from a mixture of intact and hydrolyzed proteins. Processing conditions will affect final product properties, as will pH, temperature and the ratio of ingredients. The blended proteins may act synergistically or antagonistically. Pouvreau provided a number of examples.

Ovalbumin is the main protein in egg white, and the purity of this protein directly influences its functional properties. Increasing the salt concentration affects the elasticity and water-holding capacity of the gel and will also have a dramatic effect on the salty taste perception of the finished product.

In yogurt manufacturing, pre-heating the milk creates whey aggregates. The pH at which you apply pre-heating is extremely important, as is the casein/whey ratio. The ratio casein/whey and the pH at heating will depend on the firmness of the yogurt targeted.

Pouvreau also noted that infant formula is produced using a blend of skim milk powder and whey protein concentrate. Heat-loading these ingredients during manufacture can result in protein instability, leading to insolubility and white flecks. Research revealed that the heat stability of the mixture, rather than the heat stability of one ingredient, determines the final stability of the infant formula.

Using a highly functional rather than a regular commercial pea protein in a sodium caseinate/pea protein blend will improve emulsion stability.

A model protein bar system was composed of roughly 45% carbohydrate syrup, 45% milk protein and 10% glycerol. Studies of these bars with combinations of sodium caseinate and whey protein isolate revealed a different hardening profile of caseinate vs. whey protein, Pouvreau said.

Protein Blends with Plant Proteins

Plant proteins are used in a wide range of products, ranging from:

Protein bars, processed meat

Infant formula, elderly and clinical food

- Heat stability and ingredient solubility
- Viscosity
- Ingredient compatibility = smart blending

But a broader and more extensive use of plant proteins is often limited by lack of dispersibility

- Increase plant protein use by blending with animal proteins
- Protein-protein interactions in various applications
- Soluble vs. commercial plant proteins

SOURCE: LAURICE POUVREAU, PH.D., NIZO FOOD RESEARCH; 2017 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

Applications utilizing plant proteins are increasing, but unique challenges are also created.

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Discovering the wonders of whey

When a blend of whey and pea proteins is heated, a number of insoluble wet pellets develop. Increasing the ratio of whey in the blend will increase the amount of soluble matter vs. insoluble matter. Results showed that whey and pea proteins co-precipitate, but the least amount of insoluble matter was produced when the pH was increased from 7.1 to 7.4. Heating longer helps to solubilize the pea protein. A pH greater than 7.0 is critical for pea protein solubilization.

Pouvreau went on to say that in a mixture of sodium caseinate and soy protein, 30% of sodium caseinate was replaced with soy protein. Without heat treatment, there was a distinct change in the microstructure and firmness of the gel. To create a gel that was closer to sodium caseinate, a heat treatment was applied to the combined soy protein and sodium caseinate. By slightly changing the pH, it was possible to produce a gel with mechanical and taste properties similar to a 100% sodium caseinate gel.

Adding 1% of soy creates a huge change in microstructure and water-holding capacity of soy/whey gels. By gradually replacing whey protein with soy protein, the stiffness of the gel decreased exponentially, while the firmness decreased linearly. Research revealed that the soy and whey proteins were creating a network and aggregating together

Most commercial soy protein dissolves poorly, producing a weak gel with a large amount of insoluble matter in the gel. Homogenization of soy protein solutions at 400/50 pressure significantly decreases the amount of insoluble matter in the gel.

Increasing the amount of regular commercial pea protein in a sodium caseinate/pea protein emulsion increases the amount of insoluble matter and decreases the stability of the emulsion. However, if one uses a highly functional pea protein, the results are closer to those of a 100% sodium caseinate emulsion.

Pouvreau concluded with the point that protein blends can be synergistic or antagonistic. Smart blending can address common obstacles and produce a finished product with a complete nutritional profile, excellent texture, cost optimization and a clean taste.

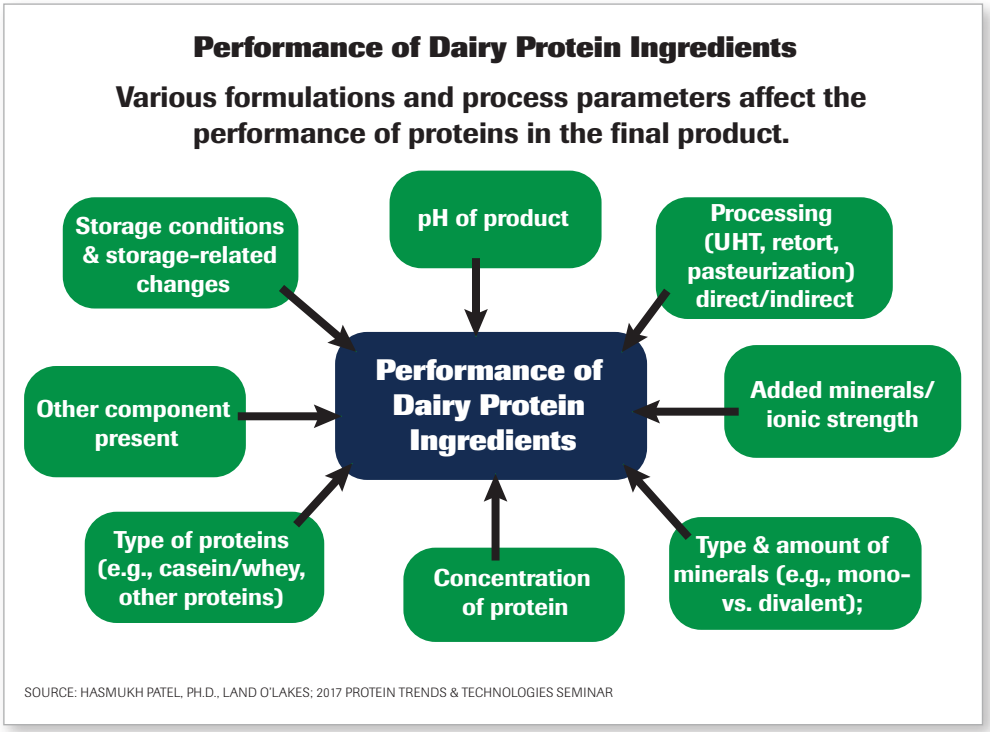
"Smart Protein Blending," Laurice Pouvreau, Ph.D., Senior Scientist Protein Functionality, NIZO, Laurice.Pouvreau@nizo.com

Unlocking the Potential of Dairy Proteins

A good understanding of protein functionality will enable food and beverage formulators to optimize protein use in a wide variety of applications including, beverages, bars, soups, sauces and retorted products. There is a structure-function relationship. "The protein type, chemical composition, structure, amino acid profile, sequence of amino acids and hydrophobicity all contribute to protein functionality in the finished product. Ingredient processing will have a dynamic effect on protein performance," said Hasmukh Patel, Ph.D., Ingredient Solutions Platform, Land O'Lakes, Inc., in his presentation titled, "Milk Protein Ingredients: Functional Properties & How to Maximize Use in Formulating Foods."

Casein and whey protein have very different structures. Whey proteins are globular proteins in their undenatured state. When heated, they unfold and interact through sulfhydryl groups and are very heat-labile. Variations in processing of whey ingredients can achieve a wide range of final textures in food products. In contrast, casein proteins are colloidal aggregates with limited tertiary and quaternary structure. Their low content of sulphur-containing amino acids in the casein and limited tertiary and quaternary structure means that they are very heat-stable.

Milk proteins contain both casein and whey in a ratio of 80/20. They are highly functional ingredients with excellent



Both formulation and process parameters affect the performance of dairy protein ingredients.

solubility and hydration properties, and add little viscosity or water-binding. Performance of dairy protein ingredients will be influenced by many factors including pH of final product; process parameters; added minerals; type and concentration of protein; other components in the formula; and storage conditions. Patel went on and discussed several protein properties.

Solubility is the ability of a protein to go into solution and remain soluble under different processing conditions. Protein ingredients with optimal solubility will minimize defects, such as chalkiness or grittiness; avoid sedimentation and floating particles; and provide desired nutritional and functional benefits, Patel said.

Compared to a number of other protein ingredients, whey protein isolate has excellent solubility over a wide range of pH levels. Factors which affect solubility include reconstitution temperature, mineral content of the water and pH of the solvent. Other formula components, such as sugar, will compete with the protein for solubility. Whey proteins are most soluble in the wide pH range from 3.0-7.0, while milk proteins or casein based ingredients perform optimally closer to pH 6.7.

Heat stability can be defined as ability to withstand severe heat treatment such as UHT or retort temperatures without coagulation, precipitation, excessive thickening, gelation or viscosity increase. Coffee creamers, soups, sauces, evaporated milk, UHT and retorted beverages, baby formula and shelf-stable products are severely heat treated. Therefore, heat stability of dairy components is an important attribute in such products.

When whey protein solutions are heated, they denature/unfold, aggregate and interact with each other. When heated at higher protein concentrations (e.g., more than 8-10% protein content), they aggregate and cross-link to form a gel. Additives, such as sugars, phosphate and citrates, can improve heat stability, as can processing adjustments including pre-heating and homogenization.

Emulsification is the ability of two immiscible liquid (e.g., oil and water) to remain in a stable solution. The proteins in milk and the phospholipids that are present in the cream and buttermilk can successfully act at oil/water interfaces to form and stabilize emulsions, thus functioning as clean label emulsifiers, Patel advised.

New developments in dairy ingredient processing are creating additional opportunities for dairy protein use. For example, innovations in membrane technology have allowed dairy manufacturers to produce a wide range of higher value ingredients, such as whey protein concentrates and isolates; milk protein concentrates and isolates; and ingredients rich in specific protein fractions. Native whey is filtered directly from fresh milk and is not a co-product of the cheese-making process. It has a cleaner flavor and better clarity than traditional whey.

Regular milk protein concentrate (MPC) has a ratio of 80/20 casein-to-whey, but suppliers can produce micellar casein with higher ratios of casein-to-whey. These milk protein ingredients have clean flavor and improved heat stability, making them valuable in applications such as retorted meal replacement, nutritional or sports beverages. Carbon dioxide treatment can be used to create MPC with improved functionality, such as better solubility, heat stability and emulsification. These MPC have superior solubility over 180 days of ingredient storage, Patel said.

Patel also explained that milk proteins have different charges at different pH. Using charged membranes, dairy processors can produce pure protein fractions, for example, alpha α-Lactalbumin (up to 97% purity) and β-Lactoglobulin isolates (up to 87% purity) without use of chromatography. This technology is currently being researched at UW Madison by Professor Etzel.

These newer dairy protein ingredients add to the list of value-added dairy ingredients that can be tailored to the needs of specific end-uses or applications, Patel concluded.

"Milk Protein Ingredients: Functional Properties & How to Maximize Use in Formulating Foods," Hasmukh Patel, Ph.D., Senior Principal Scientist and Section Manager, Dairy Foods Research and Development, Land O'Lakes, HPatel@landolakes.com

A heart-felt thank you goes to the speakers, sponsors, tabletop exhibitors and attendees who dedicated their valuable resources to making this event a success. We invite you to mark your calendar for the 2018 Protein Trends & Technologies Seminar that will take place on May 22-23, 2018, again in the Chicago area. [www.globalfoodforums.com/2018-protein-seminar/]

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Target audience: Food & Beverage R&D/Product Developers

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Protein Trends & Technologies Seminar

May 22-23, 2018 • Westin Hotel, Itasca, Illinois, USA

May 22nd Pre-conference "*Business Strategies*": Critical protein ingredient market and trend information for those making strategic business decisions in the protein ingredient industry.

May 23rd Technical Program "*Formulating with Proteins*": Focuses on the development of protein-enhanced foods, beverages and nutritional supplements. Presentations on the food science behind protein ingredients. Consumer interests, emerging nutritional benefits and regulatory issues are also covered.

Target audiences:

May 22nd - Suppliers & Industry Executives • May 23th -Food & Beverage R&D/Product Developers

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October 23, 2018 • Hyatt Hotel, Oak Brook, Illinois, USA

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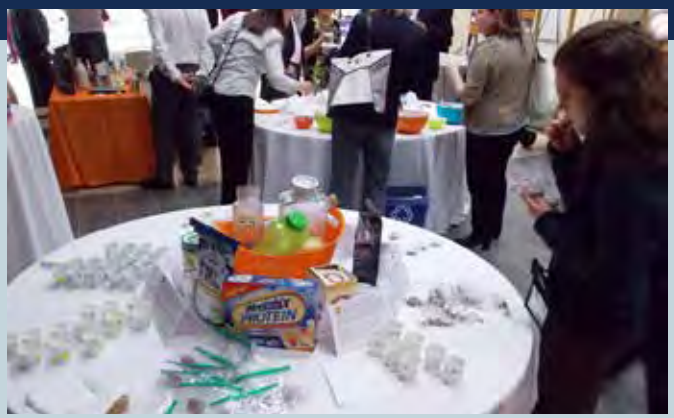

Protein Sampling Station

Products—Online! One of the most popular aspects of the Seminar: Many new products promoting their protein content have been introduced in Global Food Forums' Protein Sampling Station during the Protein Trends & Technologies Seminars. To see and read about these products online, go to www.globalfoodforums.com/trends-new-protein-foods-beverages-nutritional-products-2017/, also https://goo.gl/rpV53F or scan the QR code, left.

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I plan on attending [ ] Tuesday Night Reception

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New 2017 R&D Report: Protein Ingredients

New market research conducted by NSM Research, Inc. surveys R&D and food application formulators on their attitudes, formulation issues and future trends, as related to their use of protein ingredients. This 87-page *Global Food Forums® R&D Report: Protein Ingredients* is now available. For more information go to: http://goo.gl/WEJ4KQ or contact Jenny Stricker at Jenny@GlobalFoodForums.com or +1.800.799.9671 ext. 1.

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