2014 Protein Trends & Technologies Seminar

Report: Formulating with Proteins

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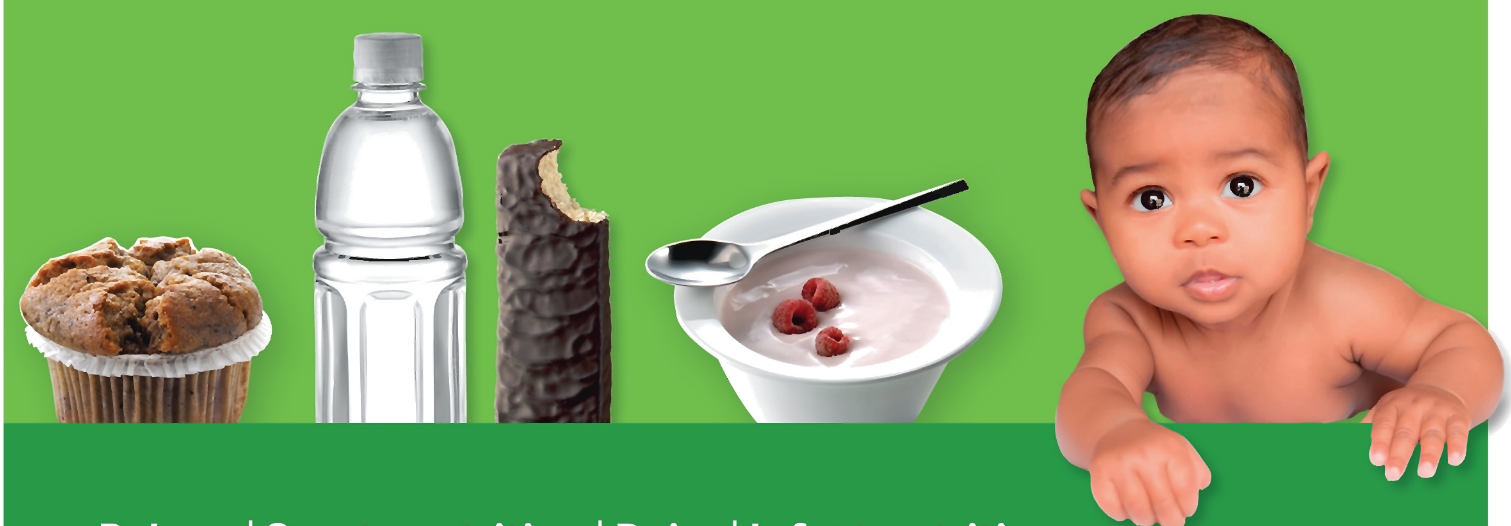

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Arla Foods Ingredients Inc.
Phone: (908) 604-8551
Email: stephen.baker@arlafoods.com
www.arlafoodsingredients.com

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2014 Protein Trends & Technologies Seminar: Formulating with Proteins

Protein foods and protein ingredients are on-trend and in-demand! Statistics from The NPD Group/Dieting Monitor show the percent of U.S. adults "usually looking for protein on the Nutrition Facts Label" steadily increased from 21% in 2010 to 25% in 2013. Euromonitor International notes that, globally, protein is an especially strong draw in emerging countries such as India, China, Russia and Brazil.

Following on the heels of its highly successful 2013 Protein Trends & Technologies Seminar, Global Food Forums, Inc. held its 2014 Seminar on April 8-9, in Arlington Heights, Ill., USA. The event was expanded to two days with distinctively different content and audiences. A Pre-conference "Strategic Insights for Business Growth" was organized for executive managers whose business decisions are impacted by the state of the protein ingredient industry. The Technical Program provided must-have information for the developers of protein-enhanced foods, beverages and nutritional products.

Once again, the schedule of expert speakers delivered insightful, valuable information. Once again, both days sold out in advance. This report summarizes information presented at the Technical Program.

All presentations or/and adapted versions are available online at http://GlobalFoodForums.com/2014-Protein-Seminar/Store

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Protein and the Global Consumer

The biggest factors that determine whether a consumer will purchase one brand's product vs. another rarely change: they are price, better taste and better nutrition. The items that typically follow are things consumers want less of, such as fat, calories, sodium, preservatives and sweeteners.

"But, the first ingredient people want put in is protein," said Barbara Katz, President of the market research and consulting company HealthFocus International, during her presentation, "Protein and the Global Consumer."

Consumer interest in protein has risen steadily in the past decade, according to Katz. After surveying thousands of customers from around the globe about brand influencers, Katz and her team have learned that people typically focus on one of two things: an ingredient or a benefit. "Protein is a rare one, where people really want to see the ingredient and the benefit," she said.

Just prior to the seminar, HealthFocus released an ingredient study that asked consumers about different ingredients: what they do and where they get them. With protein, respondents fit into roughly three groups: those that get protein from specific foods or supplements; those that know they'll get it through their generally healthy diet; and those that don't take any specific measures relating to protein.

To closely examine that first group that actively seeks out protein, Katz looked at a database of about 12,000 respondents to a similar survey. Globally, 38% of consumers qualify as "protein seekers," but that ratio varies from region to region.

"I went into this thinking the majority were going to be younger, but they're not," Katz said. "In other words: there are protein seekers in every age group."

The HealthFocus data extracted other interesting information about protein seekers, including their tendency to be more health-conscious. Protein seekers say they eat healthier and are more active than their counterparts in the general populace. "They also consider themselves more knowledgeable about health and are more proactive," Katz said.

While protein, in general, has an extremely high awareness around the globe, soy and whey are lesser-known. According to HealthFocus' findings, 81% in Europe, 83% in Latin America, 91% in Asia and 97% in the U.S. know about plain old protein. By contrast, only roughly two thirds of people know about soy, and about one third know about whey.

When asked by HealthFocus about what a protein does, consumers most often said it helps improve physical energy. An interesting outlier from these findings was the perception that it improves mental energy, as well. A mere 19% of 18-24 year-olds have that opinion; that number slowly climbed among the age groups, until it peaked at 37% among 55-64-year-olds.

Interestingly, consumers' answers changed when it came to soy and whey. Of those consumers that say they know about whey protein, most said it benefits sports/workout performance. Soy consumers, meanwhile, say it's just generally good for one's health.

Many of HealthFocus' findings suggest consumers have merely a general understanding of protein's benefits, but nothing specific or well-defined, Katz said.

Barbara Katz, President of HealthFocus International, may be contacted at bkatz@healthfocus.com or 727-821-7499.

Protein Seekers Tend Toward Healthier Lives

Always/usually:	Total	Protein Seekers
"Eat healthy foods"	68%	82%
"Give up convenience for health benefits"	36%	52%
"Avoid some favorite foods in order to eat healthier"	38%	55%

"HealthFocus Global Trend Study," 2012

Consumers who look for protein in their diets tend to make healthier choices. Protein is one aspect of their healthier lifestyle.

Communicating with Consumers: Regulations on Protein Claims and Ingredients

New protein ingredients are developed for a number of reasons, such as replacing allergenic proteins, providing more gluten-free or vegan options, or satisfying consumer demands for "natural" or "healthier" food options.

As explained by Kathy Musa-Veloso, Director, Ph.D., Health Claims and Clinical Trials, Food and Nutrition Group at Intertek Scientific and Regulatory Consultancy, "In the U.S., introduction of 'novel food' ingredients is typically conducted via the GRAS-exemption procedure to avoid the costly delays associated with pre-market approval by FDA as a food additive."

Determination of GRAS status in the U.S. is unique in the global world of food regulations, as evaluations are completed by the manufacturer (self-GRAS), who consults experts qualified by scientific training and experience to evaluate the safety of substances directly or indirectly added to food. Views are based on scientific procedures or experience based on common use in food (prior to 1958).

Musa-Veloso stated, "Pivotal data must be generally available to the scientific community. If the food was in common use prior to 1958, less scientific evidence is required. There must be evidence of substantial history of consumption by a significant number of consumers. If common use of the food was outside the U.S., then two independent sources must confirm history and circumstances of use."

In Canada, "novel foods" are defined as those not having a history of safe use; or a food that has a process not previously applied to that food; or one that causes the food to undergo a major change; or is derived from a GMO plant, animal or microorganism. Novel foods require pre-market notification, rather than pre-market approval, in Canada.

Safety considerations unique to proteins include not only an evaluation of their potential allergenicity, but also an assessment of the levels of certain inherent toxins and other bioactive components. Limits on naturally occurring toxins may need to be established. Examples include glycoalkaloids (α-solanine and α-chaconine), a group of natural toxins specific to the *Solanaceae* family of plants (potatoes). Erucic acid is a natural toxin in canola, while soybean isoflavones may be undesirable in children at high levels.

Environmental impurities, such as pesticides, heavy metals and aflatoxins, also need to be considered. Processing impurities, such as lysinoalanine, can be produced in proteins that are subjected to prolonged exposure to high temperatures and/or alkali conditions. Acrylamide can be produced under conditions where proteins rich in asparagine are heated in the presence of reducing sugars. Trypsin inhibitors are common in significant quantities in plant-derived protein isolates. Toxicology studies may be needed, as determined on a case-by-case basis.

Food Safety Labels in North America

	U.S.	Canada	Mexico
Relevant Legislation	Food Allergen Labeling and Consumer Protection Act (FALCPA)	B.01.010.1 of the Food and Drug Regulations	Mexican Official Standard (Norma Oficial Mexicana) NOM-051-SCFI/SSAI-2010
Scope	Food Allergen Labeling and Consumer Protection Act (FALCPA)	Pre-packaged foods	Pre-packaged foods and non-alcoholic beverages
Effective Since	January 1, 2006	August 4, 2012	January 1, 2011
Allergens	Milk Eggs Fish Crustaceans Shellfish Tree nuts Wheat Peanuts Soybeans	Milk Egg Fish Crustaceans Shellfish Tree nuts Wheat or triticale Peanuts Soybeans Sesame seeds	Milk Egg Fish Crustaceans Shellfish Tree nuts Soybeans

Intertek Scientific and Regulatory Consultancy

Allergen regulations are remarkably similar in the U.S., Canada and Mexico.

When it comes to claims, various types exist for proteins in the U.S., including nutrient content claims, structure/function claims and health claims. Claim regulations differ across jurisdictions from U.S. to Canada to Mexico and the EU. In Canada and the U.S., protein quality must be considered in determining whether a food qualifies for a protein nutrient content claim. In Canada, the Protein Efficiency Ratios (PER) is used to determine protein quality, while in the U.S., the Protein Digestibility Corrected Amino Acid Score (PDCAAS) is used to determine protein quality. In the EU and Mexico, protein quality is not considered in determining whether a food qualifies for a protein nutrient content claim.

With respect to allergens, there is remarkable similarity across the three jurisdictions in foods that are considered top allergens.

Opportunities abound for the development of new proteins that are non-allergenic, gluten-free and of high nutritional quality. In several key markets globally, there are mechanisms to communicate the health benefits of protein.

Kathy Musa-Veloso, Ph.D., Director, Health Claims and Clinical Trials for Intertek Scientific and Regulatory Consultancy, Kathy.musa-veloso@intertek.com, www.intertek.com, 905-542-2900, x293

Protein in Support of Skeletal Muscle Health: The Science Behind Recommendations for Athletes and "Mere" Mortals

Muscle loss with aging (sarcopenia) is an important issue. Studies show that maintenance of muscle mass and strength can reduce risk for chronic health problems and is accomplished by the elderly through protein consumption and exercise.

"If strength is a function of skeletal muscle mass, then the data suggests two things. The greater strength/muscle mass means reduced risk for death, all-cause or cancer-related, especially for those over 60 years of age. And, aging people need to practice strategies to retain muscle, such as physical activity and adequate (spaced and timed) high-quality protein," explained Stuart M. Phillips, Ph.D., at McMaster University.

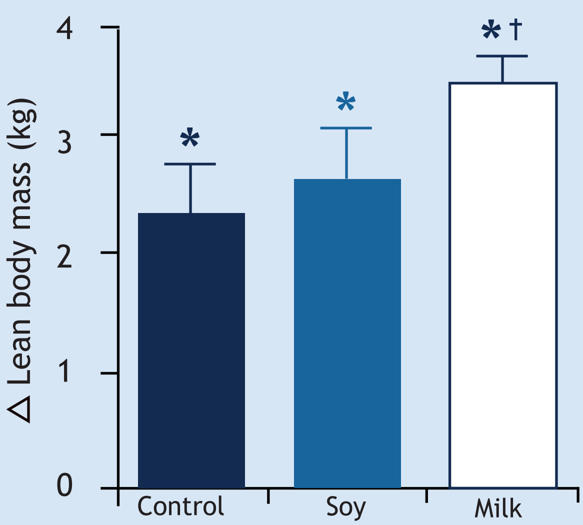
Data suggest that there is an advantage to consuming more protein than the RDA suggests, especially for older persons. However, aging is associated with reduced food intake, predisposing the elderly to energy-protein under-nutrition. One study showed that nitrogen excretion, muscle area and strength decreased in older subjects fed an isocaloric diet containing protein at the RDA. Phillips speculated that there would be greater benefit seen with higher intakes, yet many older adults are not consuming these intakes.

Athletes are another story. They do things that most others do not—such as losing 26lbs in 10 days to make weight to quality for an athletic event—but strength and endurance must be preserved at all costs. They may want to gain 15lbs of muscle in a 16-week off-season training program to make the team, but not lose speed. Or, they may need to get down to 4-5% body fat prior to the Olympic Games, for the springboard competition, but maintain muscle mass/strength/power.

Phillips went on to state that variations in protein synthesis affect muscle mass and are affected by protein ingestion and loading. After exercise, studies show that, in young men, the optimal amount of protein intake for a maximal rate of muscle protein synthesis is ~0.25g protein/kg per meal. This maximally stimulates muscle protein synthesis after resistance exercise.

Milk and Muscle Mass

Milk is More Effective than Soy and Sport Drinks for Gaining Muscle Mass



From Hartman et al. *Am. J. Clin. Nutr.* 86(2):373-81, 2007.

After 12 weeks of resistance training, young men consuming milk achieved greater lean mass gains than those consuming soy or a control group. Data suggest higher levels of leucine in whey protein in milk trigger muscle protein synthesis, leading to gains in muscle mass.

In elderly men, ~0.38 g protein/kg per meal is shown to maximally stimulate muscle protein synthesis after resistance exercise.

Phillips presented a theoretical calculation showing that younger persons who wished to optimize muscle protein synthesis at each meal feeding should be eating, at most, four times daily (4 times 0.25) plus a larger pre-sleep meal, to counteract overnight loss of muscle mass, as to promote optimal repair/recovery of muscle protein (0.5), for a daily protein intake of at least 1.5g protein per kg, per day.

Phillips stressed that this was a minimal estimate, based on studies from isolated proteins. In addition, there is an upper limit of ~2.2g protein per kg per day beyond which protein can be consumed—but is not likely contributing to gains in muscle mass.

Protein source is also important. Post-exercise consumption of milk promoted greater net protein balance than soy. Milk proteins are more effective in promoting protein accretion following resistance exercise than soy proteins, Phillips concluded. After 12 weeks of resistance training with milk consumption, significantly greater lean mass gains were shown in young men than those consuming soy or control. Milk is so effective, due to its combination of "fast" (whey) and "slow" (casein) proteins.

When whey is consumed, the rise in the blood levels of amino acids is more rapid than with casein or soy consumption. Whey promotes a greater increase in both rested and exercised muscle protein synthesis and is more effective than soy or casein in promoting anabolism following exercise. Whey is shown to promote a greater rise in muscle protein synthesis than casein, at rest or with resistance exercise in older men. Whey protein is more effective than soy, and 40g is better than 20g in stimulating muscle protein synthesis. Data suggest high levels of the amino acid leucine in whey are acting as an effective trigger for muscle protein synthesis.

Finally, Phillips said we need to dispel the myth that too much protein causes kidney and liver problems. This is categorically incorrect, as there is no data linking higher-protein diets to renal disease, as agreed upon by the IOM and the WHO/FAO reports.

Stuart M. Phillips, Ph.D., Exercise and Metabolism Research Group, McMaster University, phillis@mcmaster.ca, www.science.mcmaster.ca/kinesiology/emrg/

DIAAS and How the World Will Measure Protein Quality

In a world where the population is growing by leaps and bounds, not only food, but the quality of that food, will become increasingly important. High-quality protein is essential for growth and maintaining a healthy body. In addition, it is imperative that decision-makers have a tool to properly assess protein quality, so they can make good decisions when it comes to creating policy, establishing regulations and ensuring the public health.

In 1989, the Food and Agricultural Organization of the United Nations (FAO) proposed that the PDCAAS be utilized as a tool for evaluating protein quality, said Joyce Boye, Ph.D., Agriculture & Agri-Food Canada. This is determined by multiplying the limiting amino acid score by protein digestibility. The limiting amino acid score is defined as "The ratio of first limiting amino acid in a gram of target food to that in a reference protein or requirement."

PDCAAS has been utilized since that time for determining protein quality. There are a number of concerns with regards to this tool, however. These include the need to establish specific analytical methods for measuring amino acids in different foods; under- or overestimating the actual bioavailability of foods, especially when it came to addressing potential amino acid availability; and a failure to account for the difference between protein digestibility and amino acid digestibility. To address these concerns and review other tools for evaluating protein quality, the FAO established an Expert Consultation group.

This group issued its recommendations in 2013. Among these recommendations were:

- Dietary amino acids should be treated as individual nutrients;
- Digestible amino acids should be used to calculate protein digestibility as opposed to digestible protein;
- When evaluating lysine, available or reactive lysine should be used;
- Ileal amino acid digestibility should be used; and
- Determinations for each indispensable amino acid should preferably be determined using humans. If this is not possible, pigs or rats should be used.

Different scoring patterns were also included in these recommendations. The recommendations included those for infants, young and older children, plus considerations for regulatory applications.

The Expert Consultation group recommended that the Digestible Indispensable Amino Acid Score, or DIAAS, be adopted to replace PDCAAS. Percent DIAAS may be defined as follows.

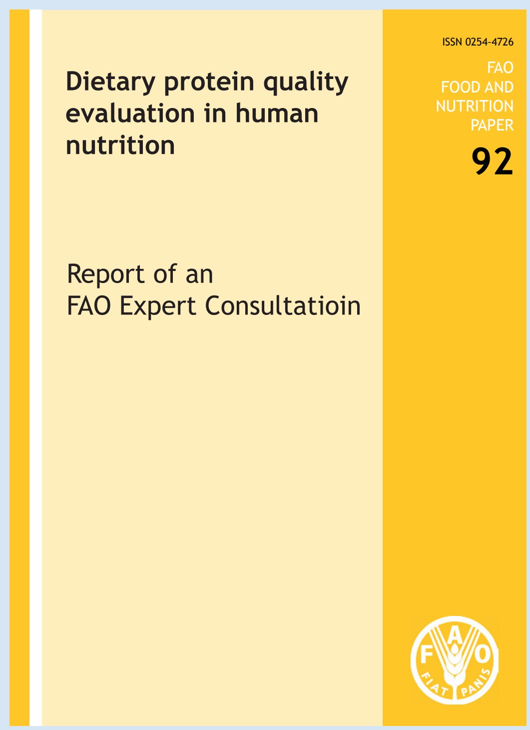
DIAAS % = 100 x [(mg of digestible dietary IAA in 1g of the dietary protein)/(mg of the same dietary IAA in 1g of the reference protein)]

The values are calculated for each indispensable amino acid (IAA) and the lowest value is designated as the DIAAS.

There are, however, challenges that must be addressed with DIAAS. One of these is the method to determine true ileal digestibility and the current dearth of data on this all-important factor. In the interim, options include utilizing protein digestibility as an equivalent for amino acid digestibility; and if true ileal protein digestibility values are unavailable, utilizing true fecal protein digestibility as a substitute; and using protein digestibility to calculate digestible individual amino acids.

There are many challenges that must be met to enhance the overall food supply and, specifically, to enhance overall protein quality. Boye concluded by listing suggestions to help move forward in reaching these goals. The suggestions were that more data is needed on the true ileal amino acid digestibility of human foods (i.e., using human and animal models) and the need for inter-species (human, pig, rat) true ileal amino acid digestibility comparisons. Also, there is a need for data on the impact of processing, anti-nutritional factors, matrix effects, etc., on protein quality and clear recommendations on practical applications of DIAAS and implications on food supply (e.g., CODEX applications).

Joyce Boye, Ph.D., Agriculture & Agri-Food Canada, may be contacted at joyce.boye@agr.gc.ca, http://ow.ly/wVIoD



To see the FAO Expert Consultation Report, "Dietary protein quality evaluation in human nutrition," FAO Food and Nutrition Paper 92, 31 March–2 April, 2011, go to http://ow.ly/wVK0T. Section 4.2, pages 22-23 provides example calculations of DIAAS and the expression of digestible amino acid contents of foods, as well as an example of DIAAS calculations for a single food ingredient and for a food mixture.

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http://GlobalFoodForums.com/2014-protein-seminar/store/.

Applying Chemistry to Solve Protein Flavoring Issues

One needn't be an industry veteran to know the consumer's bottom line is taste—and its close companion is flavor. Yet, as more proteins find their way into everything from sports beverages to energy bars, product developers face the attendant challenge of managing the flavor issues these in-demand ingredients present. Robert J. McGorrin, Ph.D., department head and Jacobs-Root Professor, Food Science & Technology, Oregon State University, opened a door onto those challenges, as well as their underlying chemistry, and presented strategies for overcoming them, in his discussion, "Applying Chemistry to Solve Protein Flavoring Issues."

Prefacing his talk with the acknowledgment that flavor can make or break a product's commercial success and consumer acceptance, McGorrin quickly got down to explaining how and why product flavor goes wrong—whether by way of heat, processing, oxidation, pH fluctuations or interactions with other ingredients—namely, proteins.

It's not that proteins themselves contribute unwanted flavors—although volatile impurities in protein ingredients (and amino acids) certainly can. Rather, it's what happens when proteins bind, absorb, release or otherwise react with constituents of the product matrix—flavor ingredients, in particular. The off-notes that result are infamous among product developers, and McGorrin presented an inventory of classic flavor defects attributable to common protein sources and ingredients.

For instance, alcohol- and ketone-containing flavors might form hydrophobic bonds with the beta-lactoglobulin proteins in whey. While these bonds are largely reversible, more permanent covalent bonds can form between aldehydes, like the benzaldehyde responsible for cherry flavor, and the amino acid dipeptide aspartame in, say, an artificially sweetened soda. When this happens, McGorrin explained, what's known as a Schiff base forms, and over the soda's shelflife at room temperature, both the cherry character and its sweetness can disappear. By analogy, the same types of Schiff reactions can occur between flavors and proteins.

McGorrin also noted that sulfur-containing flavors, like mercaptans and thiols, can form disulfide bonds with the amino acids cysteine and methionine, yielding burnt-rubber and cabbage off-notes, particularly in retorted beverages. And, there are more reactions where those came from, all with sufficiently complex chemistry. As a rule of thumb, he said, flavor-binding strength and propensity are related to protein type, with soy and whey binding more readily than gelatin, casein or corn, generally speaking.

Bringing matters back to the benchtop, McGorrin turned his focus to protein-boosted products—beverages in particular. He noted they are on the more challenging end of the formulation spectrum because of their high water activity

Definition of Selected Flavor-Protein Interactions

- **Flavor Absorption**
  Trapping of volatile flavor compounds onto non-volatile food constituents (e.g., proteins)
- **Flavor Binding**
  Covalent bond formation; hydrogen bonding; or hydrophobic interactions between flavor and protein
- **Flavor Release**
  - **Aroma**
    Availability of aroma compounds to be freed from the bulk of the food into the gas phase for sensory perception
  - **Taste**
    Availability of non-volatile compounds to be freed from the bulk of the food into the aqueous phase for sensory perception

http://chubbylemonscience.blogspot.com

Proteins interact with flavor molecules in a variety of ways. These are a few of the more common terms used to describe these interactions.

(A_w) and being part of a "dynamic" product medium. Because protein beverages are normally thermally processed, flavors often change during heating, or are lost by reactions with other ingredients (flavor "scalping"). However, beverages also often have advantages in regards to flavor stability, since they are usually refrigerated.

McGorrin quoted colleagues who say formulators often have to use flavors "by the bucket-load"—upwards of four to 10 times the normal amount—to counter act losses and changes that take place in beverages formulated for high-protein content. He then laid out four hypothetical challenges that high-protein formulations often face, and several strategies to address them:

1. **Flavor congruency:** When dealing with general protein off-flavors, consider following what McGorrin calls a flavor congruency approach—the formulation equivalent of "If you can't beat 'em, join 'em." In other words, if the challenge is an earthy pea protein or a beany soy protein, select a flavor profile that's supposed to include those "off" notes, like peanut or nut flavors. Or simply co-opt the off-flavor as part of the intended profile. In this case, a green note in a soy protein could round out a "jammy" strawberry into a more true-to-fruit flavor.
2. **Soy's bitterness:** When soy proteins encounter low pH levels, bitterness results. McGorrin credited vanilla and peach flavors with masking both that bitterness and soy's notorious beany notes. And, if the beverage can be processed either with high shear or

nano-processing, he added, the improved emulsion stability will contribute creaminess and improve flavoring efficiency.

3. **Bitter blocking:** Another way of addressing bitterness, McGorrin went on, is to counterbalance it with increased sweetness. However, in an era of calorie restriction, that may not be an option. The solution here, he said, is to use bitter blockers that "distract" the senses from the bitterness. He listed sodium chloride, monosodium glutamate and adenosine monophosphate as examples, but noted that flavor houses can build proprietary solutions.

4. **Avoiding astringency:** When whey beverages drop below a certain pH—3.5 is often the cutoff—they can become astringent, which is the sensation that comes from the interaction of saliva proteins with constituents in the drink. One hedge against this is to raise pH—but that introduces protein-stability and beverage-clarity issues. Alternatively, McGorrin suggested adopting a tropical flavor profile, such as mango, pineapple and coconut, all of which can overcome bitterness. Peach, citrus and apple can also counteract some astringency, he added.

Regardless of the challenge or solution, McGorrin recommended working with suppliers early and often in the R&D process. While one doesn't have to disclose deep formulation secrets, data about moisture content, pH, heat processing, storage conditions, percentage protein, and the addition of other vitamins, minerals and high-intensity sweeteners can help flavor partners put together a successful and efficient flavor solution that cuts time to market and makes good on both the promise of protein and a company's promise to its consumers.

Robert J. McGorrin, Ph.D., Department Head & Jacobs-Root Professor, Food Science & Technology, Oregon State University, email: Robert.mcgorrin@oregonstate.edu.,
http://oregonstate.edu/foodsci/

Emerging Protein Ingredients: Processes and Properties

Emphasis is currently being placed on the sustainability, low cost and nutritional properties of plant-based proteins as an alternative to the established animal-based proteins that are currently in the market. "Global population increases, along with the need for greenhouse gas-reduction and efficient land and water use, make it necessary to rethink protein sources and production processes," said Nienke Lindeboom, Ph.D., Senior Scientist for POS Bio-Sciences.

Protein interacts with water in food systems, creating various important functions. Examples include aeration, foaming, oil and water binding, emulsification, solubility, viscosity, gelation, film formation, cohesion, texture and flavor. Lindeboom explained that the complex structure of proteins is the reason for their varying and broad functions.

Protein structure dictates charge, hydrophobicity and iso-electric point, she noted. The environment around the protein, including pH, temperature, salt type and concentration, also effect protein functionality. Protein denaturation and gelation occur due to heat, extremes of pH and ionic strength.

These environments result in a loss of proteins' ordered structure, which causes hydrophobic groups to become exposed and reduces solubility. This, in turn, reduces biological activity; increases water-binding capacity and other functionalities; and decreases a protein's ability to crystallize. To a certain extent, these changes are often irreversible.

Examples of Emerging Protein Sources

Protein Source	Properties
Quinoa	Has a complete amino acid profile. Non-allergenic, non-GMO. Little functional information available. Co-product with small granule starch and saponins. Quinoa a consumer trend.
Rice	Recovered from bran or as starch co-product. Currently marketed as an ingredient or protein supplement. Low in lysine.
Oat	Beta-glucan and starch co-product. Low gluten, used in bread and baked goods, bars, meal replacement shakes and meats.
Flax	Co-product from oil. One commercial product is a combination with flax mucilage. Product marketed as guar gum replacement in gluten-free baked products. Provides water-holding capacity, viscosity, heat settling and crumb structure.

POS Bio-Science

Opportunities exist for novel protein sources.

Emulsification is important in such foods as margarines and salad dressings. Proteins align at the interface between two phases (e.g., water and oil) and reduce risk of instability, which would result in creaming, flocculation and coalescence of the oil droplet. Protein foaming is seen in meringues, whipped dressings and beer, where hydrophobic amino acids face toward the gas phase. Stability is best near a protein's iso-electric point. More viscous protein solutions tend to form more stable foams.

Soybean is the largest plant-based protein source and is available in isolate, concentrate and textured forms. Soy is a complete protein with a PDCAAS of 0.9 to 1. A health claim is allowed in the U.S. for soy protein, where 25g per day of soy protein may reduce the risk of heart disease. Allergenicity of soy protein is, however, an issue. Depending on product and composition, soy protein may have a slight off-flavor (e.g., grassy, bitter due to lipoxygenase actions, saponins, isoflavons). Soy protein is, however, a good emulsifier, film former and has favorable gelation properties in many applications, said Lindeboom.

Wheat protein, the most known source of gluten, is the second largest plant-based protein used. It is limited in lysine, so its PDCAAS is low. Wheat protein is comprised of gliadin and glutenin. Wheat protein has poor water solubility, foaming and emulsification properties, but excellent viscoelastic, thermosetting and water-holding properties. It has a good flavor profile and is low in price.

Pea protein is non-GMO, is not a known allergen and contains no gluten. In agriculture, the low-water usage and nitrogen fixation properties of pulse crops makes them more sustainable than some other protein crops. Peas are low in cysteine and methionine, but high in lysine, resulting in a PDCAAS of approximately 0.65, although many other values are given.

Pea protein properties and applications depend on the method used for isolation, which result in different albumin, vicilin and legumin ratios. This likely explains the differences in behavior between various pea protein products on the market and those described in the literature. Generally, pea proteins show good water binding, gelation and emulsification—but lesser foaming properties.

Other types of protein that are under development or that have recently entered the market include potato, rice, canola-rapeseed (mustard), quinoa, oat, flax, hemp, algae and leaf material.

Lindeboom noted that, to utilize low-cost proteins, the physiochemical properties need to be understood and tailored to the intended use. The development and understanding of soy protein as an ingredient for the food industry can, therefore, serve as a model for the utilization of other plant-based proteins.

Complete crop utilization, the ability to reach significant scales of production and price, and an increase in knowledge of functionality and product application will all contribute to the advancement of novel types of proteins as ingredients in the food industry.

Nienke Lindeboom, Ph.D., Senior Scientist, POS Bio-Sciences, pos@pos.ca nlindeboom@pos.ca, +1.306.978.2825, www.pos.ca

Challenges and Solutions When Working with Protein and Fiber

Protein and fiber are added to food systems for many reasons, both functional and nutritional. However, with their addition comes the need for ingredient and processing adjustments, depending on the final food and its desired characteristics.

"The approach that works for us," explained Martha Porter of Merlin Development, "is to first identify all issues through searches of literature, marketplace, patents, competitive products (both retail and restaurant) and analogous foods. Then robust experimental design optimizes taste, cost, process and shelflife. Finally, confirmation runs verify the design predictions."

Porter went on to highlight key considerations when using protein in low-, intermediate- and high-moisture systems.

Low-water Systems: In low-water systems, such as protein bars, texture changes over shelflife. Protein tends to increase firming over time, beyond the normal firming that takes place. Proteins are not fully hydrated immediately and, over time, they draw moisture from syrups generally used to hold bars together. Fiber, if it is not fully hydrated, can also draw moisture from the syrup. The continuous syrup phase then becomes more concentrated, contributing to the loss of pliability.

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Formulating foods with both fiber and protein provides additional challenges.

"Strategies to overcome these issues include use of multiple sources of protein and fiber," said Porter. In addition to protein powders, nuggets or crisps can be high in protein and also contain fiber. Coatings can be protein- or fiber-fortified. Cereal pieces, like oats, wheat flakes, nuts, pulse flour, or pieces and seeds, are other sources of protein and fiber. Protein hydrolysates are helpful to mitigate firming.

Low-DE syrups promote chewiness and help maintain pliability. They contain longer-chain carbohydrates that hold onto water better and provide cohesiveness. Higher-DE syrups add sweetness; multiple forms of sugar (sucrose, fructose, etc.) in the same binder system can hinder recrystallization. Sugar alcohols control water activity and browning. Typically, granola or cereal bars need a water activity below 0.65, with pH in the acidic range.

Intermediate-water Systems: Intermediate-water systems like bread have sufficient water to hydrate ingredients, such as fiber and protein, but there is limited room for their fortification due to other necessary functional components. For example, dilution of gluten creates problems with volume and texture in bread.

In bread, protein considerations include clean flavor and color, especially in white bread. Non-white breads can incorporate pigmented particulates, like nuts, seeds and other whole-grain ingredients. Fibers can include resistant starches and maltodextrins, which are digestion-resistant, but behave like starches and maltodextrin. They can help mitigate the heavy texture seen with high-cellulosic fiber breads. A blend of different fiber sources may be necessary to achieve both nutrient content and organoleptic quality. Other formula and processing adjustments may be necessary as well, said Porter.

High-water Systems: In beverages, protein selection depends on the desired characteristics of the final product. If clarity is desired, acidified proteins are needed. The proteins used will also depend on the desired function of the beverage or nutrition claims. Ionic strength, pH, fat and carbohydrate content, and processing parameters, such as temperature and shear, affect final product characteristics. For fiber, the focus is on nutrition, but beverages need fibers with a minimal impact on viscosity, explained Porter. High-protein and -fiber solutions can be gritty, which can be masked by viscosity. Soluble fibers may be more helpful, as can smaller particle size.

Processing parameters in beverages that need consideration include rehydration time; heat stability of the protein; and turbidity after heat treatment and fiber dispersibility. Homogenization and emulsion formation, batching temperatures, order of ingredient addition (critical for an acidification step) and packaging (clear or opaque) also help determine final product qualities.

In summary, determination of the rationale behind product fortification is first and foremost. Different moisture levels determine how to approach the formulation issues. Protein and fiber selection can be critical to product success. Process considerations also matter.

Martha Porter, Scientist, Merlin Development Inc., 763-475-0224, mporter@merlindev.com, www.merlindevelopment.com

Insights into Protein Analysis, from Commonly Used Methods to New Developments

Protein is vast and complicated and, as such, needs equally complex methodologies to analyze it. Joe Katzenmeyer, Chemistry Supervisor of rtech Labs, provided a crash course on the subject.

"I like to tell people that the work my lab does bridges the gap between very traditional technology and very modern technology," Katzenmeyer said, adding that his lab analyzes between 1,500-2,000 protein samples per month.

On the traditional side, there's the Kjeldahl Method, which has evolved quite a bit since 1883 and is still widely used. In it, samples are boiled in sulfuric acid to convert the nitrogen into ammonium sulfate. The distillation involves adding sodium hydroxide and steam heat to release the nitrogen as ammonia; then the ammonia is captured in a boric acid solution that is titrated with hydrochloric acid.

"The majority of our work is done by this method. In a good day, we have two shifts that can run about 10 racks of samples," Katzenmeyer said. "It's our most high-throughput method and the most commonly used for nutritional labeling."

Protein Separations

Method	Comment	Equipment Cost	Testing Cost (per sample)
Kjeldahl or Dumas	•High throughput •Quantitative •Universal	$50,000-$75,000	$20-$30
Gel Electrophoresis	•MW separation •Limited resolution •Difficult quantification	$5,000-$10,000	$50-$75
HPLC	•Interactions other than MW •More quantitative than gel	$50,000-$100,000	$100-$250
HPLC-MS	•Separation and identification capabilities •Large amounts of data	$250,000-$1,000,000	

Joseph Katzenmeyer, Ph.D., rtech laboratories from Land O'Lakes

Testing costs for protein analysis vary widely, and the choice of which protein-separation method to use depends on factors such as speed and resolution.

The Dumas Method is another traditional technique for protein analysis that involves the combustion of the sample and collection of the resulting gases. It involves far fewer chemicals and far less time than Kjeldahl, which is increasing its popularity, Katzenmeyer said. It involves applying high heat in a pure oxygen atmosphere; collecting gases; removing carbon dioxide and water; and analyzing the remaining nitrogen with a thermal-conductivity detector.

Both the Dumas and Kjeldahl methods are highly precise, with easily comparable results, but they have some obvious drawbacks. Non-protein nitrogen can be interpreted as protein, so one doesn't know which proteins are involved, and one needs a multiplication factor to turn the nitrogen content data into protein.

More modern methodologies rectify those issues, and separation systems have been developed to determine the presence and amount of non-protein nitrogens and individual proteins, such as myoglobin, denatured/undenatured whey, casein and alpha-lactalbumin.

Gel electrophoresis, for instance, uses electricity to separate and quantify protein macromolecules and fragments based on their size and charge. Liquid chromatography is another example, which takes liquid proteins (often dairy) and passes them through a column for the same purpose. There is also mass spectrometry, which ionizes the components of a sample with an electron beam and then separates them with electromagnetic fields.

Of the more recent methods, however, near-infrared reflectance is most on the rise because of its incredible speed. It uses an infrared light directed at the sample, which causes vibrations in the chemical bonds and creates an energy spectrum that is analyzed and calibrated. "You could have a protein content reading on the production line in, say, 30 seconds," Katzenmeyer added.

These recently developed methods, while more informative and specific, are generally more costly to execute. "They don't separate very well, which is the difficulty with proteins. Imagine you have 10,000 proteins—you can't fit all those peaks [one for each protein] in one little window. So, it gets much more complicated; more labor-intensive; and more expensive," Katzenmeyer said.

Joseph Katzenmeyer, Chemistry Supervisor of rtech Laboratories, may be contacted at JBKatzenmeyer@landolakes.com or 651-375-2207.

Katzenmeyer ended his presentation—and the seminar—with a room that was still nearly full. The enthusiasm of the attendees was a testament to the strength of, and interest in, the protein ingredient industry. Global Food Forums, Inc. again wishes to thank everyone who contributed to this event. Its success, in every respect, means this event will continue to be held.

See http://globalfoodforums.com/proteinseminar for future events.

Up-coming Global Food Forums, Inc. events:

2014 Weight Management Technologies Seminar, September 30, 2014, Itasca, Ill., www.GlobalFoodForums.com/2014-Weight-Management

2015 Clean Label Conference, March 31-April 1, 2015, Itasca, Ill., www.GlobalFoodForums.com/2015-Clean-Label

2015 Protein Trends & Technologies Seminar, May 5-6, 2015, Oak Brook, Ill., www.GlobalFoodForums.com/2015-Protein-Seminar

Arla Foods Ingredients, Sponsor of the 2014 Protein Trends & Technologies Seminar Report

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Peter O'Donnell, Art Director

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