

2013 PROTEIN TRENDS & TECHNOLOGIES

A Seminar Report

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2013 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

Proteins are hot! Consumers' belief in the health benefits of proteins has sky-rocketed, and food manufacturers are responding with a wide range of new and reformulated products to meet this demand. Noting this interest, Global Food Forums, Inc. saw a need for an in-person event that would provide compelling, must-have information for the developers of protein-enhanced foods, beverages and nutritional products.

On April 10, 2013, the Protein Trends & Technologies Seminar was held in Arlington Heights, Ill., USA. World-class speakers were assembled to discuss the international protein market; consumer and product trends; regulations; up-to-date nutritional information; and insights into emerging and applied protein food science. The highly successful conference sold out a month in advance. This report summarizes information presented that day.

- ***Muscling to the Top: Insights, Growth and the Promise of Protein***
Tom Vierhile, MBA, Innovation Insights Director, Datamonitor, a unit of Informa plc.
- ***Strategic Insights into the Global Protein Ingredient Market***
Christopher Shanahan, MBA, Global Program Manager-Food and Feed Ingredients Practice, Frost & Sullivan
- ***Protein Packing Products: The Nutritional Rational***
Christine Steele, Ph.D., director, Science, Innovation & Education, Abbott Nutrition
- ***Product Claims: Navigating FDA/FTC Regulations***
Judie Dziezak, JD, MS, principal, Dziezak Law Firm, P.C.
- ***Pulses: From Global Staples to On-trend Products***
Chef Charlie Baggs, President & Executive Chef, Charlie Baggs, Inc.
- ***Emerging Protein Technologies for Formulation Solutions***
Edward Sliwinski, Ph.D., head of the Protein Centre, NIZO food research
- ***Using Protein-rich Components to Achieve Desired Labeling***
Scott Martling, MS, Group Leader R&D, International Food Network

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➔ Proteins are the second-most plentiful substance in the body, after water, and are comprised of 20 different amino acids linked together in different combinations. Essential amino acids cannot be made by the body, therefore need to be consumed. Complete proteins, such as meat, poultry, fish, milk, eggs and cheese, provide all essential amino acids. Recommended amounts for protein vary by age, from 13g per day for young children to 56g per day for men beyond age 70, noted Tom Vierhile, Innovation Insights Director for Datamonitor, in the keynote presentation “Muscling to the Top: Insights, Growth, and the Promise of Protein.”

“According to a 2012 IFIC survey, consumers see a tight connection between protein and muscle-building, and body-building supplements have helped promote this link,” Vierhile relayed. “Athletes and teens are seen as most likely to benefit from higher levels of protein, while the need for older consumers to consume protein to maintain muscle mass is not understood,” he added.

Consumers do not associate protein with weight gain,

even though all sources of calories play an equal role. Instead, consumers view sugar, carbohydrates and fats as the primary drivers of weight gain. Protein’s healthy halo is attracting consumer attention. Interest in protein has grown quickly, and consumers are seeking out high-protein products. Some 33% of shoppers in the “Shopping for Health 2012” survey, conducted by Rodale Inc., *Prevention* magazine and the Food Marketing Institute, say protein content is of concern to them when they read product labels, according to Vierhile. Recently, a link between the consumption of a high-protein breakfast and appetite control has emerged; this may shift the focus on satiety-related products toward breakfast.

The popularity of plant protein sources appears to be rising. Data from SPINScan Natural (52 weeks ending January 19, 2013) shows that nut butters and nuts are among the top-growing categories in natural supermarkets. Plant protein health links are becoming more overt; for example, Planter’s Nut-rition is touted as an “Energy Mix” for energy enhancement. Pea proteins could also

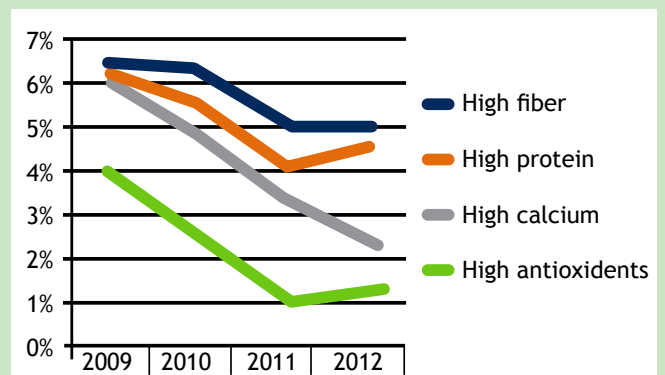


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Knowing the protein source is becoming more vital, with consumers reading labels and wanting more details on the products they consume.

Rebounding Protein Claims

(% food and non-alcoholic beverage new product reports making stated claim; U.S. new product launches only)



Source: Datamonitor’s Product Launch Analytics

After declining over the past few years, protein-fortification claims are starting to rise again, in absolute terms and relative to other major fortification claims.

be the next big thing, with more products using it and advertising the fact. Economics is likely playing a part in the popularity of plant protein relative to animal-based proteins, with low-income households, younger consumers, Hispanics and obese consumers all stating that protein is too expensive.

“Protein health claims had declined over the past few years but are rebounding,” Vierhile explained. (See chart “Rebounding Protein Claims.”) Outside of meat substitutes, dairy products, like Greek yogurt, dominate the “high-protein” claims list, with breakfast foods rising, as well. (See chart “Categories with the Greatest Change in Protein Claims.”) Meat snacks are still a big trend, now reaching a new generation of consumers with innovative jerky products. SymphonyIRI data shows double-digit sales grown in both 2011 and 2012 for jerky. Vierhile profiled a number of significant new products, such as

Archer Farms’ High Protein Cinnamon Cereal, Protein Ketchup, IPS Egg White Chips and ProYo High Protein Frozen Yogurt.

Marketing Protein Types

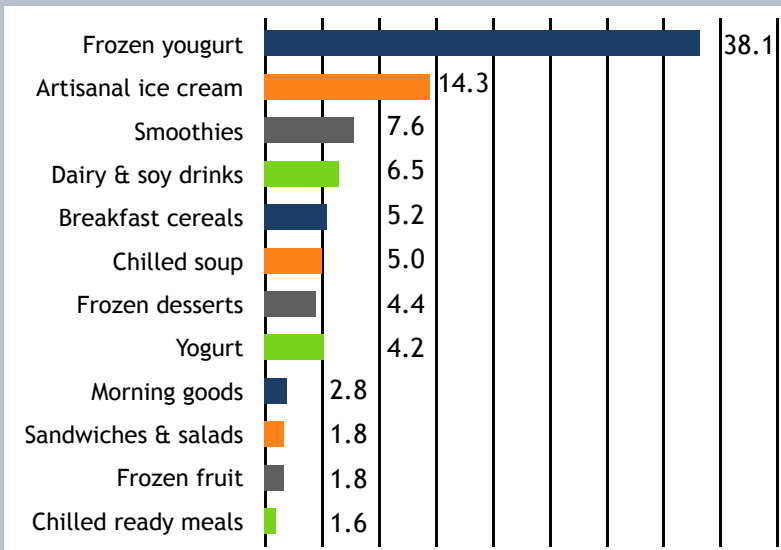
The big trend in protein right now may be plant proteins, but whey, while at times more expensive, has a huge advantage, since plant proteins are generally not as nutritionally complete. A big opportunity exists to educate consumers on the role of dairy proteins, Vierhile advised. The key is to get the message right. Knowing the protein source is vital, with consumers reading labels and wanting more details on the products they consume. For example, some whey-containing products promote that the whey is obtained from grass-fed cows, promising traceable milk while being free from hormones, like rBST and rBGH.

Vierhile predicted that local, artisan protein products could be one growth area; one such example is Wisconsin-based tera’swhey protein, made in small batches.

Another area of opportunity lies with whey protein from goat’s milk, which is said to be easier to digest for some people than whey from cow’s milk. And, concerns about food allergies and sensitivities could change the protein future market. Food allergies among young people rose 18% for the decade ended in 2007. What could be next: an emphasis on allergen-free protein?

Vierhile also said evidence is emerging that sarcopenia, the age-related loss of skeletal muscle mass and function, can accurately predict future mortality in middle-aged and older adults. Protein consumption by older consumers is not where it should be in order to help delay the effects of sarcopenia. Packaged foods and beverages targeted to at-risk, older consumers are generally few and far between, yet 27% of seniors in the

Categories with the Greatest Change in Protein Claims



Source: Datamonitor’s Product Launch Analytics

Food and beverage categories showing the fastest increase in “high-protein” claims range from yogurt and soup to ice cream and chilled ready meals. Frozen yogurt and breakfast cereal are two rising categories to watch.

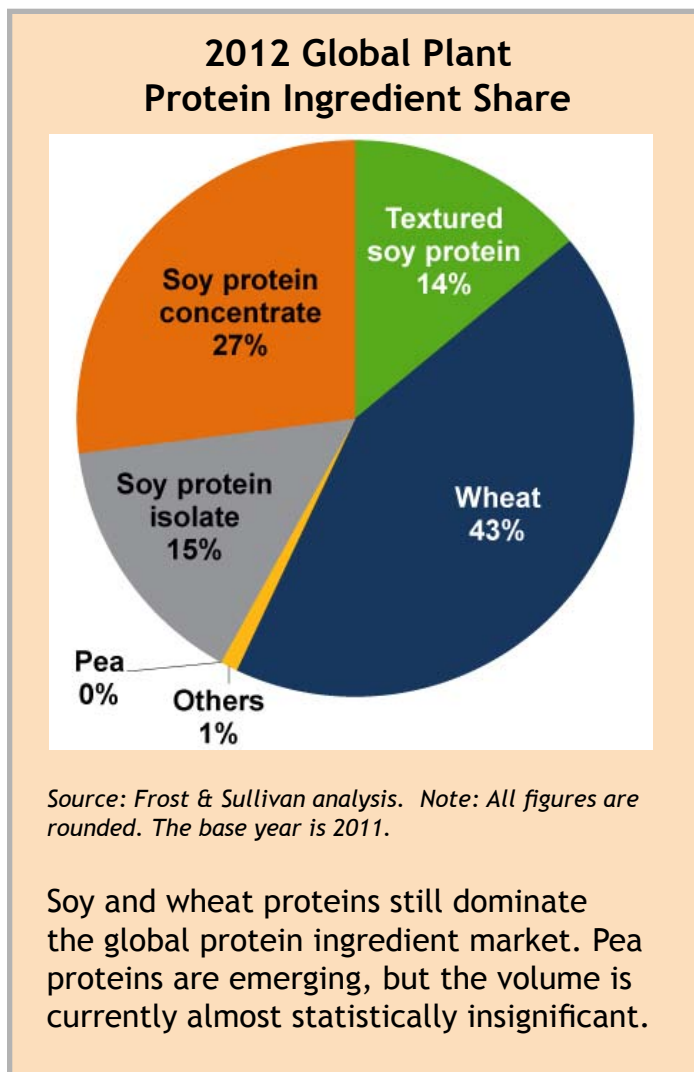
U.S. are not consuming the amount of protein they need to maintain health, he added. This, too, opens an area for growth.

With consumers gaining insights into the health benefits of proteins, and companies using proteins as a way to differentiate their products, the future is promising for this dietary component.

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Protein Ingredients, a Global Market

The protein ingredient market is highly competi-



tive and fragmented. There are many sources of proteins that compete for a limited number of end applications. "This makes the importance of quickly identifying and addressing opportunities and threats critical," explained Christopher Shanahan, Global Program Manager, Food Ingredients & Feed for Frost and Sullivan, in his presentation "Overview of the Global Protein Ingredients Market."

A large variety of protein ingredients exist from both animal and plant sources. Dairy, egg and gelatin comprise the animal sources, with a wide range of dairy types that include milk protein concentrates (MPC); whey protein concentrates (WPC) and isolates (WPI); whey protein hydrolysates (WPH); and caseins and caseinates. Plant proteins include those from soy, wheat, peas, rice, potato and canola. Soy proteins are available as soy protein isolates, concentrates and textured soy protein.

Shanahan relayed that the global market volume demand for proteins was 2.3 million metric tons in 2012 and predicted revenue CAGR to be 5.5-6.0% for the years 2012-2018. In 2012, the largest ingredient share of the global animal protein market was held by egg proteins at 40%, followed by casein and caseinates at 13%, with gelatin and WPC35 (i.e., 35% protein) each at 11%. MPC had a 10% share, with WPC80, WPI and WPI at 7, 5 and 3%, respectively, according to Frost & Sullivan analysis. Soy proteins dominate the plant protein market. See chart "2012 Global Plant Protein Ingredient Share."

Protein fortification in food and beverages is a key imperative to meet global challenges in nutritional deficiencies, noted Shanahan. Animal proteins typically provide complete protein, but soy is one of the few plant sources that also provides a complete protein. There has been a notable shift toward plant-derived proteins that offer similar or superior functional properties. Sensory properties are key to successful penetration of plant protein ingredients into applications dominated by animal proteins, as well as for development of new applications.

Shanahan explained, “The soy industry has enjoyed success by proactively positioning itself as a sustainable food/protein source; however, low consumer awareness of non-soy proteins has restrained growth of other key plant proteins.” Interestingly, cost-competitiveness is a low-impact driver, despite the cost difference between plant and other proteins being significant (between 30-50%). Health and wellness trends are the primary engines of growth in the protein ingredients market. “Among functional ingredients, proteins score very high in terms of future potential, due to their unequivocal health benefits and greater consumer recall of this benefit,” he added.

Weight management is a fast-growing segment. Positioning as a satiety ingredient is a key advantage for protein ingredients, especially since proteins are perceived as natural. Gluten-free or soy-free claims are possible with animal protein ingredients. On the other hand, environmental impact of animal proteins, primarily dairy, has been the subject of debate. Regulations around sourcing, processing, packaging and labeling are currently being tightened. “This is advantageous for animal proteins, which have had ample time to stabilize their positions regarding regulations,” offered Shanahan.

Pointing out that he was “protein impartial,” Shanahan noted that all proteins tend to have competitive advantages in one area or another. Dairy proteins enjoy the

best nutritional and flavor profile, and they remain dominant in specific end-use applications, such as sports nutrition. Egg and gelatin are difficult to replace in bakery and confectionary applications. Plant proteins enjoy lower carbon footprints and higher sustainability, as well as low price and desirable nutritional profiles. Plant proteins score lower on sensory properties, and genetic modification is an issue for greater acceptance in Europe, he said. Increased potential exists for dairy and plant protein blends; condition-specific nutrition; and improving protein delivery through further research and development.

One ongoing challenge is that a significant structural shift in price growth has occurred in the last 10 years. “Rising raw material costs, and the associated difficulties with transferring the increase to customers, will likely affect profit margins during the next decade,” he said.

“All of this information is interesting, but how can it be utilized to a company’s advantage?” Shanahan asked rhetorically. By filtering opportunities and threats, mega trends

and specific opportunities can be identified. Through detailed analysis of specific opportunities, actionable data and outcomes in each market can be recognized, he advised. Protein opportunities can be assessed through a systematic-growth consulting approach. Changing economics; concerns with food safety, health and wellness; and “going green” are addressed, and opportunities are



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Skeletal muscle functions in mobility, balance and physical strength; and provides a protein and amino acid pool to support survival during periods of metabolic stress.

optimized with this Growth Model. The core objective is to identify a company's "Growth Zone," or those opportunities which have been optimized and validated based on strategic objectives and capabilities, taking the opportunities in the marketplace into consideration.

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Update on Protein Nutritional Attributes

"Protein is vital in the body for body systems and functions, such as the immune system and hormone function; proper digestion, transport and absorption of nutrients;

and regulation of blood volume and movement. Protein promotes muscle tissue growth and repair after strenuous exercise," explained Christine Steele, Ph.D., Director of Science, Innovation, and Education at Abbott Nutrition, in her presentation entitled "Protein Packing Products: The Nutritional Rationale." She went on to explain that lean body mass (LBM) includes muscles, organs and bone; generally, everything except fat. LBM accounts for approximately 75% of normal body weight, and muscle is the largest component of LBM.

"Skeletal muscle functions in mobility, balance and physical strength; generates heat (energy); and provides a protein and amino acid pool to support survival during periods of metabolic stress," stated Steele.

Complete proteins are those containing all of the es-

essential amino acids in amounts that meet human requirements to prevent deficiency. An incomplete protein is too low in one or more of the essential amino acids. Complementary proteins are a combination of proteins that, when added together, result in a complete protein, i.e., beans and rice. Legumes can be generally low in methionine and high in lysine, while grains are the opposite—so they complement each other to form a complete protein source if consumed together.

Protein quality is measured by a number of methods. Examples include Biological Value (BV); Protein Digestibility (PD); Net Protein Utilization (NPU); Protein Efficiency Ratio (PER); and Protein Digestibility Corrected Amino Acid Score (PDCAAS), Steele said. The FAO/WHO assesses protein quality with PDCAAS, where complete proteins have scores of

Protein Consumption Recommendations

| Population | IOM RDA (g/kg body weight/day) | Range to Optimize Body Composition & Health (g/kg body weight/day) |
|-------------------------|--------------------------------|--|
| Infant to 1 year | 1.5 | |
| Children 1-3 years | 1.1 | |
| Children 4-13 years | 0.95 | |
| Children 14-18 | 0.85 | |
| Adults 19-59 years | 0.8 | |
| Adult endurance athlete | 0.8 | 1.2-1.4 |
| Adult strength athlete | 0.8 | 1.2-1.7 |
| Adult 60 years or older | 0.8 | 1.0-1.3 |
| Dieting adult | 0.8 | 1.2-1.6 |

Source: De Souza 2010; FAO/WHO/UNU 2007; IOM 2005; Layman 2009; Lejeune 2005; MSSE 2009; Mojtahedi 2011

The Institute of Medicine recommends that protein consumption increase during pregnancy and lactation, as well as during trauma and high metabolic stress. Premature infants also have increased protein needs. Increasing protein to optimal levels promotes healthy LBM in sports recovery, dieting and aging.

1.00 and include milk, egg and soy proteins. Recommended daily requirements for adults are based on grams dietary protein per kilogram body weight per day and based on intended population (lifespan/age, pregnancy, etc.). For example, the Institute of Medicine recommends 0.8g/kg body weight per day for adults 19-59 years, which is approximately 65g per day of protein for a 180lb (82kg) individual, or approximately 47g per day for a 130lb (59kg) person. (See chart “Protein Consumption Recommendations.”)

Protein requirements increase during pregnancy and lactation, as well as during trauma and metabolic stress. Many Americans consume adequate protein by this standard; however, adequate intake may not always be optimal for health or performance. Steele looked more closely at recent research into protein’s benefits in sports, weight management and during aging, said Steele.

Sports. Protein needs in athletes may rise with increased physical activity and vary with type of activity. A recognized performance organization recommends endurance athletes consume 1.2-1.4g protein per kilogram body weight per day, and strength athletes to consume 1.2-1.7g per kilogram per day. However, increases in protein intake do not necessarily deliver enhanced performance alone, noted Steele.

Studies continue to investigate types of proteins and times to consume protein for optimal results. For just one example, research by Churchward-Venne, TA, et al. published in a 2012 *Nutrition & Metabolism*, concluded that in order to maximize muscle strength and size, it was recommended that 20-25g of whey protein (or cow’s milk) be consumed immediately following exercise. The biochemical effects of exercise last for at least 24 hours and up to 48 hours after exercise, depending on the exercise type, intensity and duration; so, steady consumption of protein within this time may be optimal to maximize protein synthesis. [The full-text article can be accessed at <http://tinyurl.com/ky9p3hl>.]

Weight Management. High-protein meals are thought to help induce satiety by acting on brain regions involved in energy homeostasis. Additionally, higher protein diets may help muscle-sparing effects when dieting. Sustained periods of negative energy balance can decrease body mass, as well as skeletal muscle mass, and consuming dietary protein at levels above recommended amounts may attenuate loss of muscle mass.

Aging. Lean body mass typically declines with aging. Sarcopenia, a loss of mass and function, is prevalent in the aging population, and their protein needs may increase, said Steele. Age-related LBM loss can be driven, in part, by physical inactivity and poor nutrient intake. Aging, physical inactivity, bed rest, illness, injury and inflammation can all drive LBM loss. LBM loss can be debilitating, with loss of physical strength and increased susceptibility to illness.

Steele concluded her presentation by offering key take-away points. First, protein sources vary in amino acid composition and quality. Protein needs also change



In 2011, FDA granted Nestlé Nutrition the first-ever qualified health claim for the relationship between atopic dermatitis and 100% whey protein partially hydrolyzed infant formula, noted Judie Dziezak.

through lifespan and with exercise, catabolic stress and recovery. Thirdly, muscle mass is key to strength, physical activity and immunity. Lastly, protein is important for helping to maintain LBM and muscle health.

A link to download Christine Steele's information-filled presentation is at <http://GlobalFoodForums.com/2013-Proteinseminar>

U.S. Regulations Impacting Protein Use

From nutrition, the seminar turned to providing regulatory information, as Judie Dziezak, JD, MS, RAC of Dziezak Law Firm, P.C., spoke on "Crafting Product Claims for Labeling and Advertising of Foods and Supplements." Her presentation centered on three points: 1) types of claims that can be made on labels and labeling; 2) enforcement of claims by various government agencies; and 3) prospective and potential protein regulations in the not too distant future.



Pulses, a primary source of proteins for many, can serve as the foundation of upscale products.

In terms of claims, Dziezak discussed health claims, nutrient-content claims and structure-function claims. She explained that health claims describe the ability of a food substance to reduce the risk of a disease or health-related condition. FDA recognizes three types of health claims: 1) those authorized by regulation (listed in 21 CFR 101.72 to 101.83); 2) health claims based on an authoritative statement by a scientific body; and 3) qualified health claims.

The first two types are evaluated by FDA under a "significant scientific agreement" standard. As this was a protein technologies forum, Dziezak pointed out that one authorized health claim is directed at soy protein and the risk of heart disease. To qualify, the food must contain at least 6.25g of soy protein per serving (25% of the effective level of 25g soy protein per day).

Qualified health claims need to have credible scientific evidence, which is a lower standard than significant scientific agreement. In 2011, FDA granted Nestlé Nutrition the first-ever qualified health claim for the relationship between atopic dermatitis and 100% whey protein, partially hydrolyzed infant formula.

Nutrient-content claims describe the level of a nutrient in a product, using terms such as "high in," "excellent source of..." and "good source." Relative claims use words such as "more" or "less" to compare the amount of a nutrient to that in a reference food. For example, Silk's website makes a claim stating "50% more calcium than dairy milk." Structure-function claims describe the role of a dietary ingredient in maintaining or affecting the normal structure or function of the body. FDA does not approve structure-function claims, but claims for dietary supplements must be submitted to FDA within 30 days after marketing and must include the DSHEA disclaimer statement, Dziezak advised.

Dziezak went on to discuss how FDA, FTC and the National Advertising Division of the Better Business Bureau enforce claims. She highlighted several recent FDA and FTC enforcement activities and cases reviewed by the

National Advertising Division (NAD), as well as recent examples of civil litigation against companies.

As for protein regulations on the horizon, Dziezak noted that on February 25, 2013, FDA finalized a rule for “gluten-free” claims, and the rule is currently at the White House for review [at the time of the April 10, 2013, seminar]. The final rule allows for food with less than 20ppm gluten to be labeled “gluten free.” Relevant to soy products, GMO labeling regulations have failed to pass in numerous states, although many countries have such legislation. Some companies, however, are reportedly turning about-face and rethinking their positions on GMO labeling. Dziezak closed by pointing out that research is now directed at protein satiety. So, in the near

future, expect to see claims being made in this light.

Judie Dziezak, JD, MS, RAC, Dziezak Law Firm, P.C., may be contacted at www.dziezak-law.com, +1.847.490.5370 or info@dziezak-law.com.

A Culinary Approach to a Protein Staple

One speaker faced the unusual challenge of giving a presentation, while also monitoring his staff’s preparation of food prototypes in a nearby kitchen. In a presentation entitled “Pulses—a 21st Century Protein,” Charlie Baggs, President and Executive Chef of Charlie Baggs Culinary Innovations, took a culinary approach on how to utilize pulses in an upscale and modern manner.

Described as an “ancient and abundant, underutilized resource,” pulses are a low-cost source of protein for much of the world’s population. Pulses are defined as the seeds from the pods of a leguminous crop, such as beans (kidney, lima and mung, to name only a very few); dry peas (chick, pigeon, black-eyed); and lentils, among others. They are a sustainable crop that is easy to cultivate and drought-tolerant, noted Baggs. Additionally, pulses are not a typical source of allergens; that makes them a viable alternative for gluten-free applications. Nutritionally, besides the 20-25% protein they contain (which can be used in a complementary manner to create complete proteins in vegetarian dishes), they also contribute relatively high levels of iron, magnesium, phosphorus and zinc. Additionally, they have a low glycemic index and, thus, can help stabilize blood-glucose levels after consumption.

While Baggs presented an overview on pulses, Chefs Shane Zimmerman (Baggs’ *Chef de Cuisine*) and Ryan McGarrity prepared over 150 servings of Mini Chicken Sausage Tacos with yellow pea flour; Lamb Lollipops with red lentil flour; and Chickpea Panisse with chickpea flour for the audience.

Baggs explained an approach to recipe/formula development advanced by his company; it is called BASICS™, which stands for Balance, Acidity, Saltiness, Intended



While Chef Charlie Baggs stood onstage presenting an overview of pulse ingredients, his staff (Ryan McGarrity on left and Shane Zimmerman on right) prepared three upscale pulse-based foods for the audience.

flavor and texture, Color and Sweetness. When applied to pulses, the use of yellow pea flour provides balance as a natural protein enhancer that can be used in baked products, drinks, cereals, porridges and snack foods. Pulses do not present an acidity challenge; they create a nice platform for sweetness. And, they can provide a balance to salt. They also complement intended flavor and texture; for example, chickpeas provide the nutty flavor and texture of hummus and *falafel*, and, depending on the pulse, they contribute minimal-to-defining colors and aromas. Some can be great carriers for flavor. On the sustainability front, they are easy to cultivate and drought-tolerant.

Baggs provided an insightful piece of advice in regards to working with new ingredients...it was simply to taste each one before incorporation into a recipe. A food scientist also presenting at this seminar strongly concurred that this was an important action to take during formula development, as well.

In battered and breaded products, the use of pulse flours in the standard bread-making process yields a crispy texture that retains its quality under heat lamps, Baggs stated. If yellow pea flour is used, it can create a yellowish color that is desirable in fried products. In another example, green split pea flour retains its pigments and can be utilized as a coloring agent (think of split pea soup). In meat products, pulse flours have a high water-holding capacity and potentially significant fat-absorption capacity, which leads to

a juicier and tenderer mouthfeel and increased yields. These attributes were showcased in both the Chicken Sausage Tacos and Lamb Lollipops. Additionally pulse ingredients can extend meat products, which leads to additional cost savings.

In baked goods, pulses should be considered for their

ability to increase water-binding capacity, fat absorption and their gelling properties—which help strengthen dough and increase dough yield. Pulse flours can also increase fiber content. Pulse flours, especially pea flour, have low fat contents (the fat is highly unsaturated), which leads to baked products with increased nutritive value, structure, crispness, loaf volume and appearance, said Baggs. One of Baggs' final slides listed examples of restaurants that carried pulse-based foods on their menus.

Charlie Baggs, President and Executive Chef, Charlie Baggs Culinary Innovations, may be contacted at +1.773.880.9108 or see www.charliebaggsinc.com. A

link to download his presentation is at the website <http://GlobalFoodForums.com/2013-Proteinseminar>.

Beyond Chef Charlie Baggs' presentation, topics covered in the afternoon turned to protein science, formulation challenges and emerging protein technologies.

Protein Chemistry and Formulation Needs

Proteins are added to food for nutritional reasons and for their functionality. Functional abilities include viscosity

Amino Acid Structure

The groups that form the side chain R can be:

- Aliphatic
- Aromatic
- Basic (positively charged)
- Acidic (negatively charged)
- Sulfur
- Hydroxy

The side chains, indicated by the “R,” are what determine the differences between amino acids and the final properties of the protein.



There are basically three different kinds of non-fat dry milk (NFDM): low-heat processed, which are used in many dairy applications; medium-heat processed; and high-heat processed NFDM. The more extensive heat treatment increases denaturation of the proteins in NFDM. This is important, because less-heated, less-denatured proteins negatively interact with the protein (gluten) in dough, which results in very low bread baked volume. Since the extra heating step is required to produce high-heat proteins, they are more expensive. This can be an issue with purchasing departments. However, low-heat processed NFDM does not function well in breads.

enhancement and water binding; gelation; aeration and foaming; and emulsification with contributions to a food's flavor, texture and color.

When formulating a food or beverage, it is advisable to first consider why a protein ingredient would be used. For example, if it is just for viscosity or emulsification, alternatives such as starch or a lipid-based emulsifier should be considered, because proteins are the most expensive macro-ingredient as compared to carbohydrates and fats. Beyond functionality, other factors that influence which protein is chosen for a product's formulation include the percent of protein within the ingredient, digestibility, allergenicity, label simplicity, desired label claims, animal welfare, and amino acid profile and score. A wide range of food components can contribute proteins at a wide

range of costs. For example, clams, such as those used in chowder, are an expensive protein source, while soy flour and soy proteins are one of the most economical. They offer good nutritional quality, and the soy industry provides soy proteins in numerous forms for specific needs.

Proteins have four levels of structure. The first degree of structure is the order of amino acids of which the protein molecule is composed. Amino acids contain an amino and carboxyl group, with additional side chains that are aliphatic, aromatic, basic and so on, which determine a protein's properties in nature. (See the illustration "Amino Acid Structure.") The second- and third-degree structures determine the three-dimensional organization of the protein chain, and the fourth degree defines the spatial relationship between the protein molecules. The

structure of a protein molecule governs the function. For example, of the two primary proteins found in milk, some 80% is casein with most of the rest being whey proteins. Casein contains strongly hydrophobic regions; has a random coil structure; and is relatively heat-stable but unstable in lower-pH environments. Whey proteins have a balance of hydrophobic and hydrophilic areas; are globular in structure with many helical segments; and are easily denatured by heat—that is, they are unstable to heat. However, they are more stable to low-pH levels than is casein.

Protein denaturation is an important phenomenon influencing how these molecules behave in food. Denaturation unfolds the protein molecule, exposing its hydrophobic side groups, enabling them to participate in reactions. Many factors denature proteins, including temperature, pH, shearing, high pressure, organic solvents, salts, (such as citrates and phosphates); and oxidizing and reducing agents, such as vitamin C (ascorbic acid) or the amino acid L-cysteine.

Other aspects are influential in the denaturing process. For example, water tends to promote denaturation, while salts and sugar can stabilize proteins. Denaturation is generally reversible under mild conditions, unless protein hydrolysis, deamidation or aggregation occurs.

When a protein molecule is denatured (i.e., unfolds), non-polar regions of the protein orient themselves toward the gas (air) or lipid phase of a food, while polar residues orient toward the aqueous (water) phase of the food matrix. When the hydrophobic groups are exposed to the aqueous phase, the protein loses solubility. Other effects of denaturation include altered water-binding capacity; potential loss of biological activity; increased viscosity of the fluid; and the protein is more susceptible to enzymes (proteases).

The Food Science of Protein Properties

Key protein properties and activities include hydration (important to solubility and viscosity-providing abilities); protein-protein interactions (e.g., precipitation and

gelation); and surface properties such as emulsification and foaming.

How proteins are processed and rehydrated directly impacts solubility. Solubility depends on the properties of both of the protein and the solvent, as well as pH, temperature, concentration and the charge of other ions. Lowest solubility occurs at a protein's isoelectric point where the molecule's net charge is zero. There is no electrostatic repulsion between molecules, and they aggregate.

Casein and soy protein have an isoelectric point of about 4.6. A protein will unfold; that is, it becomes increasingly denatured the further it is above or below its isoelectric point. Under more acidic conditions, proteins are more positively charged, which is an important consideration for many beverages. The charge becomes more negative as the solution's pH increases.

Gelation is an example of an important protein-protein interaction. For example, casein and whey proteins form a gel structure typically found in yogurt. If the protein content is increased, such as through the addition of milk or whey protein concentrates or by ultrafiltration, a tighter, more cross-linked, denser protein gel network is formed. This structure is typical of Greek yogurt.

Fundamental food science can also explain proteins' ability to stabilize emulsions. Since proteins are amphiphilic, i.e., molecules that have affinity for both polar water and non-polar phases of food, such as oil, they tend to locate at oil-water interfaces. This reduces interfacial tension between the two phases, and the emulsion is stabilized. In order for this to happen, proteins must move to the interface, unfold (denature) and expose their hydrophobic groups to interact with the lipid (i.e., oil) phase.

For example, egg yolk proteins stabilize the oil-in-water emulsion of mayonnaise. The addition of an acid, such as vinegar, assists by lowering the pH and increasing protein unfolding. As proteins are adsorbed onto the interface (surface) between the water and oil phases, viscosity also increases. This further increases protein's ability to hinder oil droplet coalescence (oiling out) in the mayonnaise.

A number of issues enter into consideration when choosing a protein-based emulsifier. Factors affecting foam formation and stability include a protein's solubility; surface viscosity at interfaces; isoelectric point; and ability to form good foams at pH extremes. For example, casein is such a great emulsifier that the fat in whipped cream does not hinder foam creation. However, egg whites work best with low-fat foams, such as angel food cake.

Proteins differ in their functional characteristics and, thus, their appropriateness for a specific formulation challenge. For example, whey proteins tend to have medium emulsifying and film-forming abilities; a large range of gelation and whipping capabilities; and are stable to heat, but less so to acid. Soy isolates tend to have medium-to-high emulsifying and film-forming capabilities; low-to-medium whipping ability; medium gel-forming ability; and are relatively unstable to heat and acid. Much is known about proteins that are commercially available. The challenge is to match protein functionality with what is needed in an application.

Emerging Proteins and Protein Technologies

With a robust background in protein healthfulness and fermentation, processing, and food flavors and textures, Edward Sliwinski, Ph.D., Head of NIZO Protein Centre, discussed the topic of his presentation, "Emerging Protein Technologies for Formulation Solutions." Sliwinski explained that NIZO possesses cutting-edge information on protein processing, functionality and use in applications. This, he stated, is due to its global expertise in protein analytical methods, separation technology, modification technologies, and functionality in applications.

For one example, "A protein's functionality can be modified for optimal flavor or texture attributes through its processing," stated Sliwinski. "In addition to commonly known dairy and non-dairy proteins, alternative protein sources also can provide opportunity," he said. For example, RuBisCo, the main protein in green plants, is thought to be the most abundant protein in the world, since green

leaves are found everywhere. Leaves contain 2-3% RuBisCo on a fresh basis. This protein is the main enzyme (Ribulose-1,5-bisphosphate carboxylase/oxygenase) for CO₂ fixation as part of the Calvin Cycle. The enzyme has been highly conserved over evolution, and its amino acid composition is in line with FAO recommendations for optimal human nutrition.

Traditional extractions of RuBisCo are often based on use of an organic solvent. The resulting RuBisCo protein is an insoluble green powder. However, large-scale alternative processing has now been developed for collecting the juice of leaves, discoloring and drying the product. This produces an ingredient that is high in protein, highly soluble (>95%), and has a neutral color and flavor. This unique protein isolate has high foam stability, high gelling capacity and optimized amino profiles. It produces over twice the foam volume at pH 4.5 as certain whey and soy protein isolates.



RuBisCo is thought to be the most abundant protein in the world. Leaves contain 2-3% RuBisCo on a fresh basis.

Another area of research involves use of “text mining” to find alternative proteins for use in foods. The goal is to develop protein blends with amino acid profiles that match currently available products, noted Sliwinski. This is accomplished through the ability to search over 500,000 known proteins while comparing their amino acid profiles. Alternative proteins and combinations thereof are then selected, based on how well they match commercially offered proteins and hydrolysates.

Sliwinski provided an example of another project where consumer demand for healthy milk alternatives drove the development of a nutritionally balanced quinoa milk analog with 4g protein per serving and fewer carbohydrates than cow’s milk.

In the area of protein processing, cow’s milk proteins, casein and whey can also be optimized based on their structures. Casein micelles contain four different caseins: alpha, beta and kappa casein, and casein nanoclusters. These micelles have little 3D structure; are only partially unfolded; and denaturation is not possible. Calcium phosphate bridges together the casein micelle structure. Different caseins have differing calcium sensitivities but are relatively heat-stable. In contrast, whey proteins, mainly beta-lactoglobulin and alpha-lactalbumin, have well-defined 3D structures with internal disulfide bridges, and denaturation is possible. Sliwinski went on to discuss one study of 32 different types of commercial milk protein concentrates—all of which were found

significantly different from each other. The differences were due to their composition and processing. Control of composition and processing will allow optimized, tailored functionality, he advised.

Understanding how proteins interaction with fat, other proteins and minerals throughout processing also facilitates optimization functionality. For example, in cappuccinos, the presence

of even a small amount of fat dramatically reduces stability of protein-stabilized foams. In another study, work with cappuccinos made with a range of skim milk of 10% down to 2.5% solids found that four-fold reduction in solids content did not influence the volume or stability of the skim milk foam, but did significantly reduce ingredient cost.



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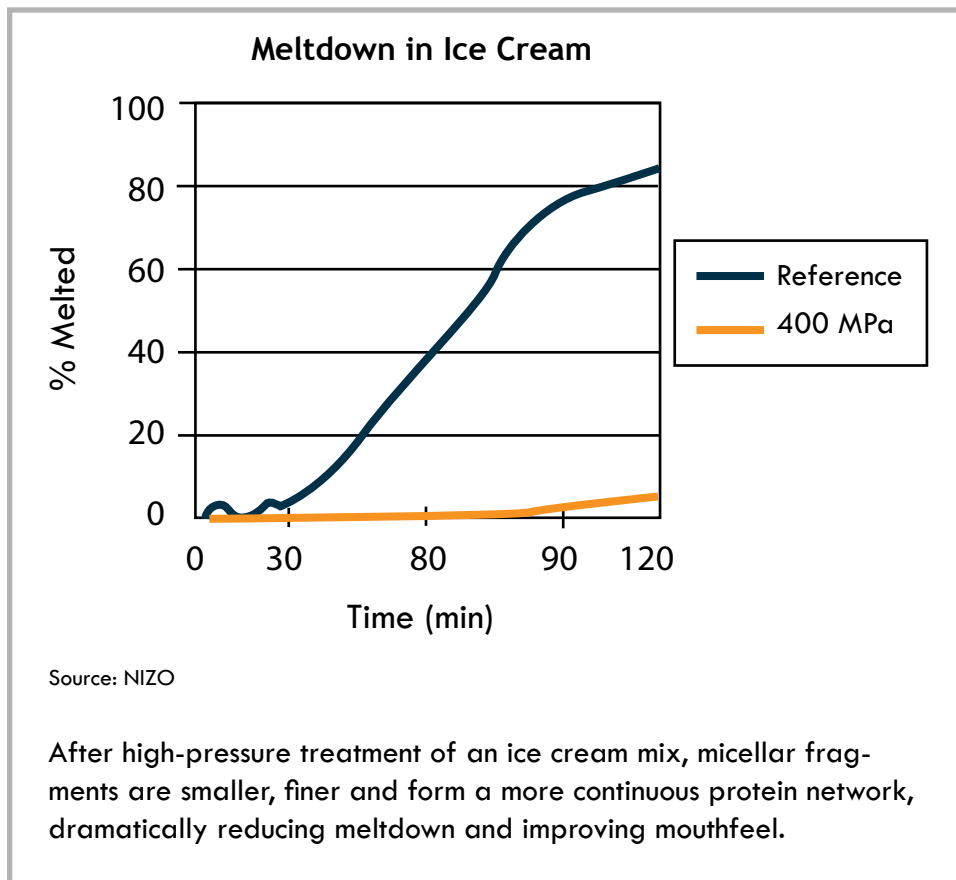
A 2012 consumer research study conducted by International Food Network reinforced the understanding that consumers want protein—they may not always know why—but they want it.

Other research at NIZO applied different processing parameters to create six different protein particle structures, while starting with the same raw material. The final ingredients were then used to address overly firm texture and hardening during storage of protein bars; overly firm textures in high-protein gels; and the problem of thickening and gelation followed by phase separation during the heating of high-protein beverages. The goal with the beverages was to keep the proteins intact (not hydrolyzed), while maintaining their drinkability. Sliwinski noted that a wide variety of foods are protein-based gels, which are adaptable by protein pre-processing. Increased texture development can sometimes also allow

for cost-reduction by increased ingredient efficiency.

Studies also have investigated high-pressure processing (HPP), which uses non-thermal technology to inactivate undesirable micro-organisms and enzymes without

Lastly, other ongoing research is looking at improving the flavor of protein products, such as the removal of beany, off-flavor (i.e., hexanal) aroma from soy drink via a targeted fermentation process.



More and more alternative protein sources are becoming available for use in food. New combinations of processing methods allow creation of new protein functions. Protein also is an excellent candidate to replace other ingredients when needed, Sliwinski concluded.

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PDCAAS: I Never Knew How that Worked!

A number of food scientists in the audience expressed pleasure with an explanation of how to calculate

affecting flavor, color or nutritional value. Commercial examples of HPP use include guacamole that has had its polyphenol oxidase enzyme deactivated, thus preventing non-enzymatic browning; juice with inactivated micro-organisms without loss of vitamins and color; and oysters with inactivated *Vibrio* spp.

NIZO has looked at HPP treatment of an ice cream mix to alter the microstructure of the protein micelles for greatly slowed meltdown. (See chart “Meltdown in Ice Cream” on this page.) Sliwinski also covered other emerging developments, such as use of enzymatic cross-linked milk proteins in cream cheese, yogurt and zero-fat ice cream. And, advances are being made in technology to structure whey, pea and soy proteins in order to provide meat alternatives with fibers and juiciness, and the “bite” of meat.

types and levels of proteins needed to maximize a food’s PDCAAS value in a formula, which was provided in a presentation entitled “Using Protein Rich Components to Achieve Desired Labeling.”

“A 2012 consumer research study we conducted indicated that protein is an exciting category for consumers; they want it—they may not always know why—but they want it. This is a tremendous category that is not going to fade away soon,” began Scott Martling, Group Leader for the R&D Firm International Food Network. However, to maximize the protein content of a product sometimes is more a matter of adding the appropriate type(s), rather than just increasing levels overall.

For example, in the nutrition facts panel, the quantity of protein is listed in grams, but the % Daily Value (DV) is not always provided. In order to list the % DV,

the protein quality must also be known as measured by the Protein Digestibility Corrected Amino Acid Score (PDCAAS). Therefore, if the % DV is not listed, a consumer will not know the quantity of complete protein of a food.

PDCAAS scores for protein quality range from 0 to 1.00, Martling went on to explain. The score represents a ratio of the complete proteins in an amino acid

A “Good Source of Protein” claim can be made on a product if it contains between 10-19% DV per serving; and “Excellent Source” can be stated if above 20% DV per serving. As stated above, the DV calculation must take into account the amount of complete protein, not just total protein; therefore, the PDCAAS must be known. Martling noted there is a newer measure for protein quality called

Digestible Indispensable Amino Acid Score (DIAAS), which may someday replace PDCAAS however, DIAAS was not covered in this conference.

Considerations when selecting proteins for a product application include not only price, solubility and taste, but also percent protein, quality, type and function of a protein. Often, confusion exists over wet vs. dry basis protein percent. As a reminder, wet basis is the amount of protein per the entire ingredient, where dry basis means the amount of protein in the solids portion of the food. Ingredient manufacturers may list either or both, and their technical representatives are the best resource for answering this question. And, while some ingredients may be less-expensive, they may have other undesirable constituents, i.e., more may be needed to achieve a desired effect. Therefore, it is often best to use the product that functions properly, even if the price is higher than an alternative, Martling advised.

A wide range of protein ingredients are available, ranging from milk, egg, soy, pea, quinoa and other plant sources, to newer trends, such as algae. Algae is an evolving, up-and-coming ingredient with up to 70% protein that is currently being grown in

Protein Content Calculations

| Quantity | | Calculations |
|---------------------|-----------------------------|------------------------|
| Ingredient X | | 12.0g |
| Solids | 12.0g protein x 95% solids | 11.4g |
| Proteins | 11.4g protein x 90% protein | 10.3g |
| Quality | | |
| Limiting amino acid | Histidine | 0.55 PDCAAS |
| PDCAAS | | |
| Digestibility | | 0.99 |
| PDCAAS | 0.55 x 0.99 | 0.54 |
| Complete protein | 10.3g x 0.54 | 5.6g complete protein |
| Labeling | | |
| Nutrition facts | 10.3g | 10g per serving |
| % Daily value | 5.6g/50g | 11% DV |
| Claim | 10-19% DV | Good source of protein |

Source: IFN

In order to make a protein nutrient-content claim, the % DV must be calculated with the PDCAAS. If ingredient “X,” for example, contains 10.3g protein per 100g, and is limiting in histidine, then 10.3g is multiplied by 0.55—leaving 5.6g complete protein. Therefore, the % DV is 11% (5.6/50g daily recommended amount for protein). At 11% DV, a “Good Source of Protein” claim can be made. These calculations may seem confusing at first, but will become second nature once done a few times, said Scott Martling with IFN.

profile of a particular food to a reference standard with fully complete protein, which has a score of 1.00. Proteins that score 1.00 include foods such as casein, egg, soy and whey.

fermentation bioreactors—which are controlled, clean environments. Algae protein is being used in novel new products and has a lot of promise and potential.

A formulation strategy for choosing complimentary protein sources in order to obtain the highest quality of protein can be compared to a peanut butter sandwich. Peanut butter and bread have complimentary compositions, with peanut butter high in lysine and bread high in methionine. When combined, they become a more complete protein. Apply this principle to a real product, such as pasta, with a content of 40% complete protein or 0.43 PDCAAS. Reformulate by adding 25% lentil flour with a higher amount of complete protein 0.71 PDCAAS, to complement the pasta and increase the complete protein. Again, it is not just protein content, but protein quality, Martling reminded the audience. In order to bring the PDCAAS of a product to 1.00—that is, in order to have all of the proteins complete—protein ingredients need to be added that bring in the limiting amino acids.

Through all this information, the take-away should be leveraging ingredients with complementary amino acid profiles. Be conscience of quantity and quality of protein. Use specifications from trusted suppliers and verify data using accredited labs. The benefit will be successful, high-quality, value-added products and happy consumers, Martling concluded.

Scott Martling, Group Leader, R&D for the International Food Network, can be contacted at Scott.martling@intlfoodnetwork.com, +1.607.257.5129 x 230 or www.intlfoodnetwork.com. A link to download Martling's calculation-filled presentation is at the website <http://GlobalFoodForums.com/2013-Proteinseminar>

Feeding the World

Throughout the seminar, presenters commented on the nutritional importance of proteins, as well as their availability and cost. However, as one speaker noted, it has been predicted there will be nine billion people on the earth by 2050. FAO data indicates that in the

last half century, milk and meat consumption has generally kept pace with population increases, but this is not sustainable. Land and water resources will not keep up with this demand. Even in the last five to 10 years, there have been significant increases in cost. New sources of protein, from algae and fungi to RuBisCo and insects, may all come under consideration. Their use as protein ingredients will depend on supply and cost, functionality and nutritional benefits, and, last but not least, consumer acceptance.



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During the seminar, a number of speakers commented on the increasing global demand for dietary protein as the world's population grows and many become more affluent.

Global Food Forums, Inc. would like to extend a very special “Thank You” to all the attendees, and to our gracious and truly gifted speakers for making this sold-out event a great educational and networking opportunity. Speaker presentation downloads are available at www.GlobalFoodForums.com/ProteinSeminar

Please watch for these up-coming Global Food Forums, Inc. events:



2013 Clean Label Conference, October 29-30, Hyatt Lodge, Oak Brook, Ill.

www.GlobalFoodForums.com/CleanLabel



2014 Protein Trends & Technologies Seminar, April 8-9, DoubleTree-Hilton, Arlington Heights, Ill. www.GlobalFoodForums.com/ProteinSeminar

Day one of the two-day program will focus on strategic business information for the protein ingredient industry. Day two will concentrate on food science, product trends and other crucial information for the formulation and development of protein-enhanced foods and beverages. Attendees will be able to register for either one or both days.



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