2015 Protein Trends & Technologies Seminar

Report: Formulating with Proteins

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2015 Protein Trends & Technologies Seminar: Technical Program

"Consumer interest in high-protein foods has skyrocketed," said Steve French, Managing Partner, NMI, during the Pre-conference: Business Strategies at the 2015 Protein Trends & Technologies Seminar. According to French, in 2014, 53% of the general population indicated they seek out foods that are high in protein. This dovetails well with International Food Information Council Foundation's "2015 Food and Health Survey," in which 54% of consumers say they try to get a certain amount, or as much as possible, of "protein" (topped only by "whole grains" at 56% and "fiber" at 55%).

Following sold-out events in 2013 and 2014, the 2015 Protein Trends & Technologies Seminar by Global Food Forums, Inc., proved to be North America's largest conference dedicated to the protein ingredient market and technologies. Held May 5-6, in Oak Brook, Ill., USA, its 231 registrants could choose to attend either (or both) the Pre-conference on May 5th or the Technology Program: Formulating with Proteins on May 6th. This report touches on highpoints from the technical program, where expert speakers delivered valuable, non-ingredient supplier-affiliated information.

All presentations or/and adapted versions are available online at http://GlobalFoodForums.com/2015-Protein-Seminar/Store.

We hope to see you at our 2016 Protein Trends & Technologies Seminar, May 3-4, Oak Brook, Ill., USA. www.GlobalFoodForums.com/2016-protein-seminar

Table of Contents

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Consumers Source Protein from Every Grocery Aisle

Protein is on consumers' shopping lists for many reasons—wellness, strength, energy and satiety among them—but what's become equally diverse in recent years is where those shoppers find it. In her presentation, "Steaks to Shakes: Protein on the Shopping List," Linda Gilbert, EcoFocus Worldwide founder and CEO, noted that 25% of U.S. consumers say they've been eating more protein in the past year, according to Mintel data.

Sectors like beverages, snacks and supplements are capitalizing on this growth. "Consumers today are diversifying their choices and shopping beyond the meat case to find protein," Gilbert said.

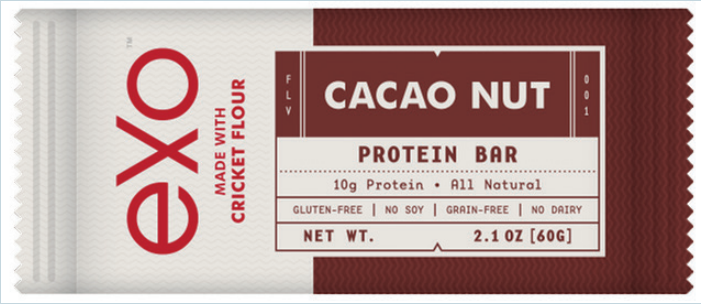
According to Acosta, the most popular alternatives to meat protein among consumers today are nuts (64%), beans/lentils (63%), dairy/eggs (56%), grains like rice/pasta/quinoa (50%) and shakes/bars (21%). Weight management is the chief reason for this rise in protein demand (46% of Mintel respondents), with low-fat, low-carb and sugar-free diets losing popularity. Gilbert credits the rise of the Paleo diet, along with gluten-free, vegetarian, vegan and allergen-free diets, as additional driving factors.

Interest among Millennials doesn't hurt, either, with 42% saying it's important to get more protein in their diet (NPD Group), and 60% believing they can achieve the necessary daily protein amount without meat (Acosta). More than 31% of shoppers say they bought meat alternatives, such as tofu and texturized vegetable protein, over the past year, but Millennials led the charge at more than 50%. Two notable product examples of this are Lightlife's Smart Patties, quinoa burgers with 10g of protein; and Quorn, a frozen food line made of fermented fungi.

Gilbert noted the snack aisle is getting significant attention for its protein products, too. Additionally, nearly all of the examples she mentioned carried non-GMO, vegan, gluten-free and/or organic claims, as well.

Protein product claims are up 54% in the past five years, according to Mintel. In the beverage category, IRI reports 91 examples in the dairy aisle (dairy and dairy alternative products) claiming to have "more protein" (36 in number); "high protein" (21); or

Sampling: From Insect Protein to Cereals, Beverages and More



Many of the new packaged foods touting their protein content shown in Linda Gilbert's presentation were available for sampling during the networking sessions. The products' ingredient lists, nutritional profiles and often price paid by Global Food Forums for some 30 foods, beverages and supplements can be viewed at http://ow.ly/LuNBy.

Products sampled included the Paleo Diet Bar, with 17g of protein from egg white powder, sunflower and sesame seeds, almonds and hemp protein powder. Macrobiotic GoMacro Bars (launched a few years ago) contained sunflower butter and organic sprouted brown rice as protein sources. The new thinkThin nut bars contained almonds, pumpkin and sunflower seeds, and soy protein isolate. EPIC's Cranberry and Sriracha jerky bites, made from grass-fed beef, turned out to be spicy-hot and quite popular with attendees.

The range of drinkable products present included Pacific Foods' Chicken Bone Broth with 9g protein per serving, and WheyCoco, a premium whey protein isolate and powdered coconut water beverage. Perhaps the most attention-getting product sampled was the Exo Cricket Flour Protein Bars, developed by a chef, with 10g of protein made with almonds, dates, coconut, flax seed and—you guessed it—crickets. Three emerging protein ingredients were also available for tasting. They included hemp protein powder, algae protein flour and 100% cricket protein powder, which had an "interesting" flavor, as noted by Professor Keith Cadwallader, who spoke on flavorings later in the program.

proclaiming a "good source of protein" (34). By contrast, they found just seven juice products with protein claims. Hood Simply Smart and Farmland Dairies Skim Plus promise more protein (25 and 37%, respectively) and are on protein beverage shopping lists most often, according to IRI (52 weeks ending 3-22-15). They likewise boast features like more calcium, no fat and an eco-friendly container, said Gilbert.

TruMoo Protein Plus is another volume leader in this category, with 25g of protein and no HFCS. New Zealand's new a2 Milk, just now being launched into the U.S. market, interestingly promises only a2 beta-casein and not a1 beta-casein, which is associated with milk intolerance, according to the company. Califia Farms' Pure Almondmilk is dairy-, soy- and carrageenan-free, with 6g of pea and brown rice protein. Suja's Organic Sunset Protein, available exclusively at Target, has 10g of vegan protein with pea protein concentrate, almonds and hemp protein powder.

When looking for protein in juice, IRI says the most popular choices are Sambazon Protein, a vegan superfood smoothie with 8g of protein; and Silk Fruit & Protein, which is non-GMO certified and has 5g of protein (52 Weeks Ending 3-22-15). Dannon and V8 have both added protein shake varieties, promising 12g of protein and high fiber. Stonyfield Farms' Orgain line proclaims the "first-ever USDA Organic high-protein shake with 25g of protein from organic grass-fed milk concentrate and organic whey concentrate," Gilbert added.

Almost 50% of shoppers that use protein shakes and/or bars use them as meal replacements at least one-two times per week, Gilbert mentioned. Millennials do so most often.

Gilbert concluded her presentation with the question: "Can protein [also] make us beautiful?" She noted collagen supplements are now on the U.S. market, and in Japan, gummy candy from Meiji contains at least 2,400mg of collagen for skin beauty. Suntory has introduced a collagen-infused beer to Japan that promises to make the drinker more beautiful.

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How the FDA's Proposed Food Label Changes Will Impact Proteins

From what can be gathered thus far (May 2015), the FDA's proposed changes to nutritional information listings will generally not impact protein ingredients directly, but they may indirectly affect them.

PHOTO CREDIT: PEGGY GREB

Nutritional requirements of nursing moms are important. The FDA has proposed the protein RDI for lactating women be increased to 71g per day.

If developing products with nutritional goals in mind for a certain claim or label, the criteria for making those claims may change, noted Riëtte van Laack, JD, Ph.D., Director, Hyman, Phelps & McNamara, PC, in her presentation "The Present and Proposed Future of Food Labels."

"These are proposed regulations, so we don't know what the end result will be. But it's clear things will change, and the industry has to be prepared to rethink certain things," van Laack said.

One of the few and possibly only changes directly impacting proteins is a proposed increase in the reference daily intakes (RDI) for lactating women from 60-65g per day of protein to 71g.

The FDA's large draft proposal centers on the need to update the Nutrition Facts box with the goal of improving how information is presented to consumers. The previous iteration of Nutritional Facts dates back to the early 1990s, and the FDA is reportedly revisiting nutrition labeling requirements out of concerns about obesity in American consumers; new nutrient definitions; new data reference intake values; new analytical methods; and new dietary recommendations, said van Laack.

A new format for the Nutrition Facts box is one proposed change. The servings and calories would be noted in a larger, bolder typeface. Calories, in particular, would appear much more prominently than now. The other notable proposed change is that the Daily Value percentage column would be moved to the left, before the individual nutritional components. As with everything

PHOTO CREDIT: SANDSTEIN

Under current regulations, free amino acids used in conventional foods are regulated as food additives, which means their addition to foods is limited. In dietary supplements, amino acids are considered dietary ingredients and may be added without restriction (provided they are safe).

in the proposal, these items may still be tweaked, and the FDA has an alternative format already prepared for consideration.

Other proposed changes focus on certain line items now commonly listed in the box. "'Calories from Fat' is slated for removal and 'Added Sugar' will be added. The FDA is now defining sugars as '…syrups, naturally occurring sugars that are isolated from a whole food and concentrated, so that sugar is the primary component (e.g., fruit juice concentrate), and other caloric sweeteners.' " Examples would be brown sugar, corn sweetener, corn syrup, honey, invert sugar, lactose, maltose, malt sugar, molasses, raw sugar, turbinado, sucrose and trehalose.

There are currently no analytical methods to distinguish between naturally occurring sugars and added sugars, so this change could add a massive record-keeping requirement for companies.

Similarly, vitamins A and C are off the mandatory micronutrients list, while potassium and vitamin D are in. Declaration of mandatory micronutrients also includes their quantitative amounts, not just their percentage of daily value. And, FDA has suggested many RDI decreases for various nutrients and a few increases (such as vitamin C and calcium).

The FDA is calling for changes to many of the Reference Amounts Customarily Consumed (RACC), which form the basis for determining serving sizes. Ice cream, for example, will move from half a cup to a full cup, and candy will decrease from 40 to 30g.

"These proposed changes may indirectly impact protein in several ways," said van Laack. They include product formulation changes due to interest in avoiding or decreasing certain nutrients. Changes in RACC may also affect a food's eligibility for claims. For example, yogurt's proposed serving size reduction from 8 to 6oz may potentially affect its eligibility for a nutrient content claim.

Lastly, the FDA may suggest more changes in response to comments submitted to them. In the six-month period it permitted comments, the FDA received 278,000 of them. Among them was criticism of PDCAAS, the method currently used to determine protein quality for percent of Daily Values. It's been noted that a 2013 WHO Report recommends replacing PDCAAS with Digestible Indispensable Amino Acid Score (DIASS).

Also at issue is the calculation of protein content based on nitrogen x 6.25 and amino acid spiking; this does not refer to the melamine problem, van Laack clarified. Rather, free amino acids used in conventional foods are regulated as food additives, which means their addition to foods is limited. In dietary supplements, on the other hand, amino acids are considered dietary ingredients and may be added without restriction (provided they are safe). However, protein content may not be declared on labels of dietary supplement products that contain only individual free amino acids.

This leaves a number of questions unresolved, said van Laack. "What about dietary supplements that contain both proteins and individual free amino acids?"

Comments by industry request FDA to revise the regulation to clarify that the declared protein content must be based on nitrogen content, calculated by using protein nitrogen content only, and may not include non-protein nitrogen content. Protein is defined as "a chain of amino acids connected by peptide bonds." Alternatively, calculation may be based on total amino acid content corrected for free amino acid content.

"Certain dietary supplement companies have already adopted this standard voluntarily," van Laack said.

The FDA is aiming for mid-2016 to finalize the proposals. The revised labels and reformulated products would be required 2.0 years later.

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Protein, Appetite and Weight Management

Advice for weight loss used to be simple: Eat less of everything. "This approach has not worked, and we are focused on identifying those unique foods and components that may play a role in weight reduction," stated Richard Mattes, Ph.D., Purdue University, in his talk "Protein, Appetite & Leveraging: Protein's Role in Energy Balance."

Further Research: Leveraging Protein for Weight Management

Quantify the contributions from:

- **Each mode of action**
- **Satiety, palatability and protein balance**
- **Protein sources, food form, pattern of intake**
- **Individual differences**

SOURCE: RICHARD D. MATTES, PH.D.

Long-term benefits of higher-protein diets for weight management are, possibly, only slight. However, several paths of further investigation into proteins' more detailed role are suggested.

Mattes posed the question, "Are all calories equal? At the molecular level, the answer is yes." "However," he noted, "several food components are of interest for weight control at the organ and whole-body level, and research is showing that the energy from each may not be equal."

Protein is one such food component that might alter other food choices. Some work indicates there might be a "protein-specific" effect, as rats deprived of protein will show a preference for protein consumption when provided access. Similar results have been noted in pregnant animals. Further, when fed a protein-restricted diet for 12 days, animals will try to "make up" the deficit when allowed protein for one hour per day.

Evidence in humans indicates that when protein-deprived, protein consumption will be favored—as evidenced by heightened intake of soup containing either casein hydrolysate or MSG—both providing cues that protein is present.

Epidemiologic data shows the intake of fat and carbohydrate varies widely between countries, but protein intake is very constant at 12-16% of energy. In the U.S. over the last four decades, both fat and carbohydrate consumption have changed markedly, yet protein levels have remained constant. This suggests a biological basis for consumption.

Mattes described the theory of "protein leveraging," which suggests human intake of protein is a primary determinant of energy intake. That is, if the protein content in the diet is low, humans will eat more food in order to meet optimal protein status. However, all three studies directly testing the protein leveraging hypothesis have not supported the theory.

While not playing as central a role as the protein leveraging hypothesis predicted, protein can alter diet or physiological functions (such as thermogenesis). Such effects may be small, but they might aid in weight management—while contributing positively to diet quality.

Several meta-analyses of shorter-term, tightly controlled feeding studies showed greater weight loss, fat-mass loss and preservation of lean mass after higher-protein, energy-restriction diets.

Leidy, et al. reviewed 24 acute feeding trials of ≥120 minutes containing low- and high-protein isoenergetic meals with different protein intakes (≥10g) and with less than 40% of calories as fat. A modest satiety effect, including greater perceived fullness and elevated satiety hormones after higher-protein meals, was confirmed, but an effect on energy intake at the next eating occasion wasn't shown, said Mattes.

People will lose weight on energy-restricted diets with or without high levels of the protein. However, diets that contain between 1.2-1.6g protein/kg/d and are consumed in a distributed fashion providing 25–30g protein/meal may provide improvements in appetite and body-weight management. Further, higher-protein diets are associated with greater retention of lean mass—which is beneficial in maintenance of loses in body weight.

The vehicle in which protein is delivered is very important. Greater satiety and a more consistent decrease in energy intake have been shown when protein is fed in solid form rather than as a beverage.

In summary, Mattes noted, "Higher-protein diets may enhance fullness under selected conditions and have higher thermogenic properties that may very modestly aid weight loss or maintenance. Such diets are associated with greater retention of lean body mass and higher resting energy expenditure, and may be associated with lower energy intake acutely. High-protein diets may promote very modest reduction of body weight and fat mass, and somewhat positively aid weight maintenance. However, these effects may require substantive increases of protein intake, a behavior change that has proven difficult for most people to follow."

Richard D. Mattes, MPH., Ph.D., RD, Distinguished Professor of Nutrition Science, Purdue University; Affiliated Scientist at the Monell Chemical Senses Center, mattes@purdue.edu, 1.765.494.0662, http://www.cfs.purdue.edu/lsis/

Structure, Functions and Applications

When a food manufacturer decides to fortify a product with protein, they must first determine the target protein level and then develop a narrative story for consumers to believe in the product. If the product is targeted for muscle-building, then the narrative

Protein Selection

	Protein	Primary Functionalities	Limiting Attributes
Traditional	Dairy	Emulsification, Gelation	Cost volatility, Lactose
	Soy	Emulsification, Structure	Soy flavor
	Gelatin/Collagen	Gelation, Water-binding	Pork/beef derivation
	Peanut	Flavor, Texture	Aflatoxin concerns
	Almond	Flavor, Texture	Cost
	Wheat	Film formation, Structure	Gluten presence
	Egg	Aeration	Unstable to heat
	Muscle	Binder, Gelation	Meat processing/Safety
	Bean	Binder, Viscosity	Bean flavor
	Algal	Gelation, Emulsification	Consumer perception unknown
	Canola	Binder	Consumer perception unknown
	Pea	Emulsification, Binder	Pea flavor
Emerging	Rice bran	Film formation, Binder	Consumer perception unknown

SOURCE: JULIE MANN, THE HERSHEY COMPANY

A simplified overview of functions and limitations of some traditional and emerging proteins provides a few considerations to their use.

will be different than if the product is targeted for weight management. The narrative builds credibility in the product, its purpose and what it stands for to consumers, said Julie Mann, MSc, Staff Scientist, Snacks and Adjacencies Research, The Hershey Company, in her presentation "The Protein Bridge: Linking Protein Structure to Function and Applications."

The target level of protein influences whether to fortify with a protein isolate, protein concentrate or whole food protein product. Potential claims might be 5g of protein to make a "good source" of protein claim; 10g to make an "excellent source" claim; or simply "x grams of protein."

If the protein does not meet protein quality standards (PDCAAS), as is the case with many plant proteins, then several proteins or additional grains may need to be combined to correct for protein quality, said Mann.

When selecting from the vast array of protein ingredients, cost and functionality are critical considerations. Mann explained: "The formulator needs to ask, what functional attributes will the protein provide? Is the ingredient readily available? Will the finished product be cost competitive, and is there price volatility?"

Meeting consumer demand for clean label and sustainability introduces other issues. Can the protein ingredient make a GMO-free claim? Has it been co-processed with other ingredients that need to be labeled? Does it allow the manufacturer to develop a narrative around sustainability: responsible water, land and fertilizer usage? These topics are becoming increasingly important to consumers today.

There are two major types of protein: globular and fibrous. Globular proteins, the predominant group, are compact, folded and generally water-soluble. Fibrous proteins, like those in collagen and gelatin, are generally less water-soluble. Amino acids are the building blocks of protein and differ by side chain.

"Understanding the amino acid composition of a protein provides insights into potential functionality in the final product. For example, if there are sulfur-containing amino acids, then expect disulfide bridges in the final product," said Mann. Egg products contain cysteine and serine, which aid in structural stability through bridging.

Proteins have a primary, secondary, tertiary and quaternary structure. Understanding the bonding that occurs within these structures also helps to predict the function and performance in the final product, Mann said.

Denaturation takes the protein from its compact native state to an unraveled state. It may be reversible or irreversible, and partial or complete. Denaturation results in decreased solubility, increased viscosity, altered functionality and some loss of enzyme activity. Denaturing agents include temperature, pH change, shear, high-pressure processing, salt addition, organic solvents, and oxidizing and reducing agents.

Finished product processing may involve additional pH and temperature changes, as well as interactions with air, acids, fat, flavoring agents and other components in the system. Protein ingredients can contribute to water binding, viscosity building, gelation, foaming, emulsification and browning. Understanding

their functionalities up front can shorten development time; ensure stable products throughout the shelflife; and inspire development of unique functions or novel products.

Food formulators should embrace both old and new protein sources. Dairy and soy are traditional powerhouses. There is growing interest in gelatin for joint health and beauty-from-within. Pulses are already eaten in many regions of the world. Emerging proteins include algae, canola, oats, flax, hemp, quinoa, rice, sunflower and lemna. Some have wider commercial availability than others. Exploratory proteins include insects, such as crickets and mealworms. RuBisCo is the most abundant protein on earth and is found in every green, leafy material. Developments in newer proteins are increasing at a rapid pace, due to the need to feed more and more people over the next 20+ years.

Industry doesn't yet know whether consumers will embrace these new ingredients, or if there will be confusion and unforeseen negative baggage. Food formulators should strive to better understand the functionality of traditional proteins, while exploring opportunities to embrace novel proteins, Mann concluded.

Julie Mann, MSc, Staff Scientist, The Hershey Company, www.hersheys.com, juliemann@hersheys.com

Processing, Characteristics and Uses of Extruded Plant Protein Ingredients

Vegetable proteins can be texturized and extruded into different shapes, forms and uses for a variety of applications. In some cases, this provides a more feasible option to increase the protein content of a food than working directly with the food matrix. While many plant protein sources can be used for texturized vegetable protein (TVP) products, soy is the most common. About 80-90% of the TVPs found in the market place today are soy-derived.

Other proteins that can be texturized include wheat, peanut, chick pea, green pea, lentil and yellow pea. But, "in order to create TVPs, the functionality, composition and behavior of the proteins used must be understood," explained Mian N. Riaz, Ph.D., Director, Food Protein R&D Center, Texas A&M University, in his presentation "Processing, Characteristics and Uses of Extruded Plant Protein Ingredients."

For example, vital wheat gluten is the primary protein component in wheat-based raw materials. It is very hydroscopic and sticky. Pea protein concentrate, with 46% protein, would typically also contain 17% starch, 18% sugars, 4% ash, 2.7% oil and 2% crude fiber. In contrast, a faba bean protein concentrate of 63% protein may contain only 0.1% crude fiber.

Soybeans can be made into flour, soy protein concentrate, grits or flakes. The process is very complex, with extractions, purification and concentration. Alterations in any step can impact the finished ingredient—and every process adds cost—which explains why soy protein isolates and concentrates are so expensive.

"Because of their higher cost, soy concentrates and isolates are rarely used alone in TVPs," Riaz said. However, their addition improves water-holding capacity and protein content. There are at least 23 different types of soy protein concentrate for different applications, so it is important to specify the application to the vendor. The goal is to understand the functionality of the raw materials to give good texturization, he added.

It is essential to know the protein level, protein dispersibility index (PDI), nitrogen solubility index (NSI), oil and fiber content, and particle size of the raw materials. All of these properties affect texture in the finished product. Higher protein levels give firmer-to-rubbery textures. For example, at a 90% protein level, a very rubbery texture occurs, which is not desired. For textured vegetable protein products, ideally, protein should be about 50-60% for a very good texture.

Textured vegetable protein products can be made to look and behave like various meats, with similar composition, appearance, texture, water absorption and rehydration time. Cooking characteristics can also be similar.

Composition of Animal Meats

	Chicken breast	Chicken leg	Tuna	Flounder	Catfish	Mutton chop	Beef brisket	Beef sirloin
% water	75	75	62	81	80	52	61	68
% protein	23	21	22	17	16	15	16	21
% fat	1	3	16	1	3	32	21	10

SOURCE: TEXAS A&M UNIVERSITY

PDI and NSI are measures of a protein's solubility in water and are related to the amount of heat treatment. "The PDI test is more rapid and tends to give slightly higher results than NSI," said Riaz. The ideal place to start for good texture is about 60 PDI. This attribute also affects color, with a higher PDI being lighter in color. Darker soy ingredients are typically used for feed, while lighter are used for human food products.

Riaz continued to explain: "Oil and fiber content reduces [the] protein level by dilution and interferes with texturization. Soy hull fiber can cross-link with protein macromolecules, affecting structure and texture; typically, in these products, less fiber is better."

When creating TVPs, native-state proteins are preconditioned with steam and water, where they begin to swell and unfold, and then cross-link during the extrusion process. Extrusion changes ingredients chemically and physically, and a new material is created. An extruder is a continuous pressure-cooker to which water and raw materials are added, and temperature is increased within seconds. Depending on the type of extruder, there are many functions it can perform. Different protein products can be created, including chunk-style, shredded or structured meat analogs in any shape, size or cut. For chunk, minced and flaked textured soy protein products, Riaz advised to use soy flour with 60-70 PDI, and 50-55% protein content.

"Important properties include water absorption, oil absorption and a meat-like texture. Color can be added to make it look like beef or chicken, and flavors can also be used," Riaz continued. Meat analogs can look and behave just like any kind of meat with similar appearance, texture, water absorption and rehydration time. Cooking characteristics are also similar to meat. Applications include vegetarian diced-meat dishes, stew meat, jerky, barbecue, pot pie, pasta and more.

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Of Allergens and Proteins

There are a lot of myths about food allergens, including the myth that certain proteins are non-allergenic. In fact, every protein has the potential to become an allergen. The key to dealing with allergens is careful management within manufacturing facilities and clear communication to consumers on the food label.

Food allergies are abnormal responses of the human immune system to substances in food. "When an individual is exposed to protein, that exposure can stimulate the creation of IgE antibodies that create sensitivity to that protein. Individuals don't have symptoms during the sensitization phase. The next time the individual is exposed to the protein, however, the body reacts and releases a host of physiologically active substances in tissues and the bloodstream," explained Steve Taylor, Ph.D., Food Allergy Research & Resource Program, University of Nebraska.

Eight foods (cows' milk, egg, crustacean, fish, peanut, soybean, tree nuts and wheat) are the most common causes of food allergy. These Big 8 are responsible for 90% of all food allergies on a global basis. Common allergenic foods in other countries include buckwheat in Japan and lupine in the EU. Kiwi was introduced into the human diet in the last half century and is now the most common allergenic fruit in Europe and the U.S., Taylor went on to say, in his presentation "Allergens—It's Really Just a Management and Communications Issue."

The most common allergenic foods tend to be consumed frequently and in relatively large quantities. With the exception of crustaceans, they are typically consumed in early life stages. Most are excellent sources of protein. Another factor that determines allergenic capability of a food is resistance to digestion in the stomach, which allows the proteins to enter the small intestine in an immunologically active form.

To predict the allergenic potential of a novel protein, one should first perform a thorough review of global allergenic literature. Explore if the protein ingredient is allergenic in other countries; if it contains a potentially cross-reactive protein; or if it is botanically related to other allergens. Insects are invertebrates, as are crustacean shellfish. Taylor recommended putting a warning on insect ingredients, such as "Not suitable for individuals with shrimp allergies."

Any novel food could potentially become allergenic.

Could Novel Food Sources of Protein Become Allergenic?

- Inevitable; reports of allergic reactions should not be a surprise
- But perhaps not commonly; prevalence will be predictable to some extent
- Not all adverse reasons will be allergic reactions (Quorn)
- Should not be a deterrent to development of new protein sources
- Clear labeling is the key

SOURCE: FOOD ALLERGY RESEARCH AND RESOURCE PROGRAM (FARRP), UNIVERSITY OF NEBRASKA

Food allergens are commonly classified into families by their shared amino acid sequences and conserved 3-D structures. Knowing if a novel food source contains any of these amino acid sequences could help predict if that food could one day become allergenic. There are four main families of plant-based food allergens.

- **Prolamin superfamily**—this includes Ara h 2, which is present in peanuts. This family includes allergens in walnuts, peanuts, sesame, mustard and sunflower. It also includes gliadin, a component of gluten.
- **Cupin superfamily**, which includes seed storage proteins, peanuts, soybeans and other legumes.
- **Bet v 1 family**, which is present in birch trees.
- **Profilins**, present in all species of animals and plants, but not a major concern, because they are heat-labile.

There are also three main families of animal-based food allergens.

- **Tropomyosins**—the major allergens of crustacean shellfish and, probably, insects.
- **EF hand proteins**, which include parvalbumin, the major allergen in fish.
- **Caseins**—the major allergens in milk.

Foods should not be marketed as non-allergenic. It would be more accurate to state that the product "contains no commonly known allergenic foods." Companies working with novel protein ingredients might consider seeking insights from the FDA as to how that organization will handle new information about potential allergens, advised Taylor. Companies should also be aware that regulations for novel food products in other countries may differ from U.S. regulations.

With clear labeling, consumers who develop allergic reactions will be able to avoid the offending food. Allergenic potential should not be a deterrent to marketing of novel food protein sources.

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Better Protein Ingredients Through Controlled Maillard Reactions

By 2020, the global demand for protein ingredients is expected to reach 4.6 million tons and generate revenues of nearly $30 billion. But proteins can be problematic ingredients, and by using modified protein ingredients, a finished product's performance can be positively impacted, said Baraem (Pam) Ismail, Ph.D., Associate Professor, Department of Food Science and Nutrition, University of Minnesota.

A common solution to several formulation challenges is to use protein hydrolysates, which can enhance digestibility, improve functionality, reduced allergenicity and and enhance bioactivity. Ismail explained this and more in her presentation "Considerations in Protein Ingredient Use: The Impact of Processing and Molecular Interactions."

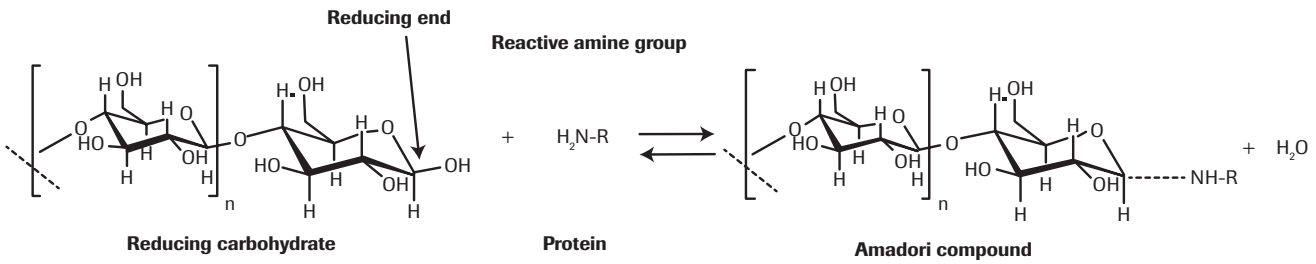
However, when proteins are hydrolyzed, they partially unfold, exposing groups that also can cause aggregation. That is, some peptides are actually aggregate promoters and will interact with other proteins, to create peptide-peptide interactions, and with carbohydrates to participate in undesirable Maillard reactions.

Aggregation is caused by both intrinsic factors, such as the source and structure of the protein, and extrinsic factors, such as heat, acid and protein concentration in the food system. Maillard reaction is an interaction of protein with carbohydrate, and its progression to advanced stages results in protein polymerization and reduced overall quality and shelflife. "One promising approach to limit aggregation is controlled Maillard-induced glycation, which involves covalent bonding of a protein and a sugar molecule," said Ismail.

Research has shown one way to eliminate Maillard reaction-induced polymerization in nutrition bars formulated with whey protein isolate (WPI) is to substitute sorbitol for HFCS, a

Enhanced stability and reduced protein/peptide interactions result when a protein is only partially glycated, and the Maillard reaction is stopped at the initial stage of an Amadori compound's formation.

Controlling Protein Glycation



SOURCE: BARAEM ISMAIL, PH.D., DEPT. FOOD SCIENCE AND NUTRITION, UNIVERSITY OF MINNESOTA

reducing sugar. This formula adjustment hinders Maillard browning reactions and the formation of high-molecular weight polymers.

Ismail discussed a study that looked at soy protein isolate (SPI) and soy protein hydrolysate (SPH) that were stored at high-water activity. The researchers monitored the change in free amine groups over time. The results showed a faster rate of aggregation in the SPH because of the release of higher levels of free amine groups that would participate in the Maillard reaction.

Solubility in beverages is a challenge when formulating with higher protein levels. Whey protein denatures between 60-70°C, causing the protein to unfold and expose hydrophobic residues and SH groups. These residues react and result in polymerization between proteins/peptides. As the polymer grows, the protein falls out of solution. At the protein's isoelectric point, solubility will be very poor.

Fruity beverages formulated with whey protein are typically formulated to a pH below 3.5 to achieve clarity. Being good buffers, the presence of proteins necessitates addition of a considerable amount of acid to reach the desired pH. An excess amount of acid, however, can result in a finished beverage that is sour and astringent. These beverages are typically formulated to less than 4% protein, but 4.2% protein is required in order to make an "excellent source of protein" claim. One study using a partially glycoated whey protein achieved good solubility at concentrations between 5-7% protein.

One way to reduce or eliminate Maillard reaction-induced polymerization in protein bars with whey protein isolate is to use sorbitol instead of HFCS, which is a reducing sugar.

Flavor Issues/Functional Foods

- **Many functional foods and beverages have "harsh" flavors, including off-odors, bitter tastes and undesirable mouthfeel properties (e.g., astringency).**
- **Many lack any inherent positive flavors.**
- **Functional foods are viewed as members of a particular food category rather than the "functional food" category.**
- **The "If it tastes bad, it's good for you" concept doesn't apply to functional foods and beverages.**

VERBEKE, W. 2006. FUNCTIONAL FOODS: CONSUMER WILLINGNESS TO COMPROMISE ON TASTE FOR HEALTH? *FOOD QUAL. PREF.* 17: 126-131.

SIRO, I., KAPOLNA, E., KAPOLNA, B., LUGASI, A. 2008. "FUNCTIONAL FOOD: PRODUCT DEVELOPMENT, MARKETING AND CONSUMER ACCEPTANCE - A REVIEW." *APPETITE* 51: 456-467.

CHART COURTESY KEITH CADWALLADER, PROFESSOR, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN.

Whey protein contains an "EF loop:" a three-dimensional structure that functions as a gate to hydrophobic residues. At the protein's isoelectric point, the gate opens, exposing the hydrophobic groups, and polymerization results. However, it is possible to change protein functionality through glycation at specific sites, preventing the EF loop from opening.

By carefully controlling the Maillard reaction, an ingredient manufacturer can stop the reaction at a specific point, before the protein is completely glycated and before progression into undesired advanced stages. Advantages of this partial glycation are: increased net negative charge on proteins; increased surface hydrophilicity; reduced denaturation rate; reduced disulfide interchanges; and increased steric hindrance due to bulky polysaccharides. The net effect is enhanced stability and reduced protein/peptide interactions.

Food formulators should get as much information as possible from their protein supplier. By understanding how a protein was processed (and possibly modified), they can more accurately predict the sweet spot of optimal protein level with good product stability.

Baraem (Pam) Ismail, Ph.D., Associate Professor, Department of Food Science and Nutrition, University of Minnesota, bismailm@umn.edu, +1.612.625.0147

Flavor Challenges with High Protein Levels

The flavor of foods and beverages brings out emotions and drives consumers' food choices. People have expectations for flavor, and if those expectations are not met, there is a problem. Functional foods often contain proteins and other ingredients that cause flavor problems.

"Linked to acceptance, flavor is the bottom line," spoke Keith Cadwallader, Ph.D., Professor, Department of Food Science

Developing a Flavor Solution

- **Reduction/removal of off-flavors in ingredients**
- **New/improved processing methods which minimize formation of off-flavors or reduce off-flavors (as a result of a process)**
  - **Reduced time/temperature treatment in processing with flash-cooling to evaporate or "flash-off" highly volatile off-odors**
  - **Create physical barriers to reduce off-flavor impact**
- **Better flavoring solutions: addition of masking agents/specially formulated flavorings**

CADWALLADER, K.R. 2015. FLAVOR CHALLENGES IN FUNCTIONAL BEVERAGES. IN *HANDBOOK OF FUNCTIONAL BEVERAGES IN HUMAN HEALTH.* SHAHIDI, F., ALASALVAR, C. (EDS.). CRC PRESS TAYLOR & FRANCIS GROUP

and Human Nutrition at the University of Illinois at Urbana-Champaign, in his presentation "Flavor Challenges and Solutions for High Protein Functional Foods and Beverages." Defining flavor quality is very important. "If a product is labeled as 'chocolate' or 'vanilla,' it needs to be identified as such immediately upon tasting," he advised.

If there is any confusion about that flavor, then it has failed. "The flavor should develop quickly, be balanced and get more desirable the longer it is tasted," added Cadwallader. Flavors also need compatible mouthfeel and texture. A chocolate beverage, for instance, should be creamy, viscous and thick—instead of watery or thin. Lack of off-flavors and minimal aftertaste are also important attributes for success.

Functional foods often contain ingredients that contribute harsh flavors and lack any inherent positive flavors. "Most people are not heard saying 'mmmm, taste that soy flavor,'" Cadwallader joked. While dairy proteins are generally pleasant, most functional ingredients are not. And functional beverages are seen by consumers as members of a food category, not a functional-food category, meaning a chocolate beverage will be compared to other chocolate beverages—not to other functional foods. Consumers do not forgive off-notes in foods and now expect high-quality functional beverages.

Proteins often have readily detectible, inherent off-flavors that are difficult to measure instrumentally. These off-flavors can often be attributed to enzyme-derived volatiles, aged proteins or lipid oxidation of bound lipids, Cadwallader went on to say. Soy protein isolate, for example, has a fair amount of retained polar lipid that cannot be separated, leading to problems.

Soy protein is often associated with a well-known beany flavor and a "cereal note" generated from Maillard reactions that typically need to be covered. Dairy proteins are better—unless they are aged, when they can develop off-notes, unpleasant odors and astringency—problems in older caseins and whey protein concentrates.

"The fresher the protein, the better; if offered a deal on some old casein, the best option would be to pass," Cadwallader advised. As protein ages, off-notes form and bind to the proteins, which are often undetected until rehydration. Other protein off-notes include pea (earthy, soil), rice (bran, rancid), egg (sulfur) and insect (an "interesting" odor).

"Fat modulates flavor release, so adding even one drop fat can make the world of difference," advised Cadwallader. Amazingly, 0.1% fat or less can completely shift the flavor profile. This lesson was learned years ago when trying to make everything low-fat or non-fat," he reminded the audience. Process-induced flavors are also an issue. A product may have the perfect flavor initially, but the process can change everything.

Cadwallader recommended first prescreening ingredients; looking for anything that might be a problem; and then, if needed, resourcing for better options. "Masking agents can also work like magic, in theory neutralizing undesirable aromatics and tastes, without imparting characteristics of their own—unless beneficial," he added.

Cadwallader suggested that a successful product is a balance between art and science. He strongly advised to work with a flavor company using non-disclosures; telling them everything about the formula, process and packaging. He recommended including flavor experts early, to provide them a mix and challenge the experts to flavor it.

Keith Cadwallader, Ph.D., Professor, Department of Food Science and Human Nutrition at the University of Illinois at Urbana-Champaign, cadwlldr@illinois.edu, +1.217.333.5803, http://fshn.illinois.edu/directory/cadwlldr

Global Food Forums, Inc. wishes to thank the speakers, attendees, sponsors and tabletop exhibitors for making the 2015 Protein Trends & Technologies Seminar a very successful event. Complimentary copies of the presentations may be downloaded from http://globalfoodforums.com/2015-protein-seminar/store. If interested in receiving future notifications of when complimentary conference special reports and presentations become available, please sign up at http://ow.ly/OsEtm.

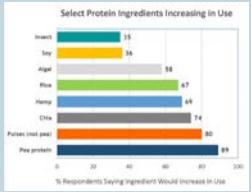
Resources on Protein Ingredient Technologies

Traffic to Global Food Forums' website (www.GlobalFoodForums.com) has steadily increased since its inception. With some 100,000 views by spring 2015, the site is a treasure trove of free access to past presentations by high-profile industry experts, as well as trends and statistics related to Global Food Forums' core conference topics. Here are some items you may have missed. Again, be sure to check out the free downloadable PDFs from presentations given at the 2015 Protein Trends & Technologies Seminar at www.GlobalFoodForums.com/2015-protein-seminar/Store.

Beyond the Yuck Factor, Insect Proteins Face Hurdles

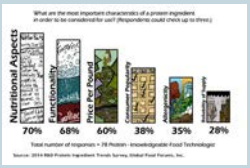
There has been an abundance of attention-grabbing headlines that promote the use of insects, particularly insect protein, for human food use. A key advantage is their ability to provide high-quality nutrients with relatively low agricultural input; they are a sustainable food source. However, despite media coverage on the topic, the reality within the food industry itself is a somewhat different story. As with all food ingredients, before proteins from insects are formulated into foods, they must meet a number of conditions. To garner insights from a key group whose primary task is to choose ingredients to formulate into products, Global Food Forums, Inc. conducted an "R&D Protein Trends Survey" among R&D food technologists attending its third annual Protein Trends & Technologies Seminar in May 2015. The "protein knowledgeable" food technologists completed a survey to assess cricket protein on eight factors that could be barriers to its use in foods, on a scale ranging from 1 (insignificant barrier) to 10 (maximum barrier). Those who tasted the cricket protein flour during a Protein Products Sampling Session gave the ingredient a total barrier score of 6.34; those that had not tried the powder responded with an even higher barrier score of 7.74. To see the complete July 22, 2015 Press Release and results, go to http://ow.ly/QCOzV or scan the QR code to the right.

Formulators Identify On-trend Protein Ingredients



The significant number of food technologists attending the "Formulating with Proteins" program at each year's Protein Trends & Technologies Seminar provides Global Food Forums an excellent way to gain opinions and insights from those who formulate with protein ingredients on a large, commercial scale. The "2014 R&D Protein Trends Survey," conducted at that year's seminar, provided such insights. In its survey, Global Food Forums, Inc. asked: "Do you see the use of the following protein types (as a powdered ingredient within formulated products) as decreasing, increasing or remaining the same in the USA in the next two years?" Those surveyed were then given a list of 17 ingredients. Pea protein was identified by 89% of the 78 "protein knowledgeable" food technologist respondents as increasing in use in the next two years. "Pulses (not pea)," "chia," "hemp," "rice" and "algal" proteins followed with 80, 74, 69, 67 and 58% of respondents, respectively, saying they would increase in use. To see the complete Press Release (just released May 14, 2015), go to http://ow.ly/QD2MS or scan the QR Code to the right.

Formulators Identify Most Important Protein Ingredient Characteristics



From algae to whey, protein ingredients are obtained from a wide variety of sources and differ from each other in key characteristics. During the design of a new food, beverage or nutritional product, product formulators choose which proteins they will use based on these characteristics. During Global Food Forums' 2014 Protein Trends & Technologies Seminar, attendees whose responsibilities included product formulation were asked: "What are the most important characteristics of a protein ingredient in order to be considered for use?" They were instructed to choose three of eight options provided. Some 70% of the "protein knowledgeable" food technologists identified a protein's "nutritional aspects" as one of the top-three most important characteristics to consider. This was followed closely by "functionality (physiochemical properties)," identified by 68% of the technical respondents. To see the complete Press Release (just released March 12, 2015), go to http://ow.ly/QIQoa or scan the QR code to the right.

Currently Under Development: Global Food Forums' Spanish Microsite

TENDENCIAS DE LA PROTEÍNA & TECNOLOGÍAS SEMINARIO

ETIQUETA LIMPIA CONFERENCIA

Global Food Forums is developing a microsite in Spanish. This site will contain industry news and formulation technologies related to the conferences of Global Food Forums.

We invite you to visit the following webpages.

Global Food Forums está desarrollando un micrositio en español. Este sitio contendrá noticias de la industria y tecnologías formulación relacionadas con las conferencias de Global Food Forums. Le invitamos a que visite las siguientes páginas.

Scan the QR code to the left to see the home page of Global Food Forums, Inc.'s microsite in Spanish. It will have links to information about Global Food Forums and who we are, conferences, trends and data, complimentary information and links to philanthropic organizations.

Esta es la página inicio del micrositio en español de Global Food Forums, Inc. Contará con enlaces a información sobre Global Food Forums y quienes somos, conferencias, tendencias y datos, información gratuita y enlaces a organizaciones filantrópicas. www.globalfoodforums.com/es/inicio/

Química de Proteínas y Necesidades de Formulación

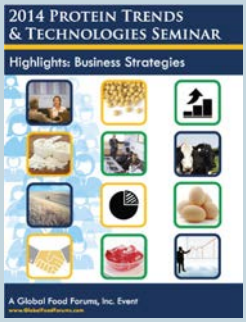
Las proteínas se añaden a los alimentos por razones nutricionales y por su funcionalidad. Las características funcionales incluyen la mejora de la viscosidad y la retención de agua; la gelificación; aireación y formación de espuma; y la emulsión a la vez que mejora el sabor, la textura y el color de un alimento. Las proteínas difieren en sus características funcionales y, por lo tanto, su adecuación para una formulación específica es un reto. Por ejemplo, las proteínas de suero de leche tienden a tener capacidades medias emulsionantes y de formación de película medias; una amplia gama de capacidades de gelificacióny de batido; y son estables al calor, pero en menor medida al medio ácido. http://ow.ly/QJ2LT

Las 10 Principales Tendencias para el 2015 con información sobre Proteínas

La tendencia hacia las proteínas sigue fuerte. Los consumidores consideran que las proteínas son saludables y los fabricantes responden a esa visión enriqueciendo sus productos con ellas. Los proveedores de ingredientes, los fabricantes de alimentos y los consumidores están en busca de la próxima fuente de proteínas. La proteína de soja es la más utilizada en los nuevos productos lanzados al mercado. La proteína de arveja crece con rapidez pero desde una base reducida. La proteína de lactosuero es popular desde hace varios años y continúa creciendo. Se anticipan más aplicaciones con proteína de alga en el futuro. http://ow.ly/QJa1M

2014 PTT Pre-conference Program Highlights Available

Attendees to the 2014 Protein Trends & Technologies Seminar's "Pre-conference: Business Strategies" were presented updates on factors impacting the global protein ingredient marketplace. The program consisted of speakers from companies such as Euromonitor International, Frost & Sullivan, Decernis, Best Vantage, Inc. and The NPD Group. Highlights from the program, including charts and statistics, can be accessed by going to http://ow.ly/RdfIQ.



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