2022 Protein Trends & Technologies Seminar

Post-Conference Magazine

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[1] *Find out more in our Environmental, Social and Governance Report (https://bensonhill.com/wp-content/uploads/2022/08/2021-Benson-Hill-ESG-Report-20220808.pdf).*
[2] *Source: Euromonitor International; Voice of the Consumer: Health and Nutrition Survey, 2021, n: 21, 459.*

2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

Welcome to the post-conference coverage of the annual Global Food Forums Protein Trends & Technologies Seminar. This is North America's largest event dedicated to the protein ingredient marketplace and applied technologies for formulated foods, beverages and supplements in food formats that use protein-based ingredients. The Seminar was held on October 25-26, 2022, in Itasca, Ill., USA.

Product developers must stay updated on evolving trends, advances in nutritional science and emerging ingredient technologies to develop successful new products as efficiently and cost-effectively as possible.

To help with this challenge, key points summarized from the event's 16 presentations are offered on the following pages and on our website, at www.globalfoodforum.com. The speakers were chosen for their ability to provide R&D and other food scientists with practical, noncommercial formulation advice; consumer and product trend information; insights into emerging ingredients, nutritional and regulatory updates.

Since 2013, Global Food Forums has published nearly 30 post-conference summaries covering proteins, clean labels and sweetener systems. See https://globalfoodforums.com/ for more information on these publications.

Additionally, some of the speakers at this and past events have made their PowerPoints publicly available in PDF format. Where available, links are given at the end of each presentation summary in this magazine.

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

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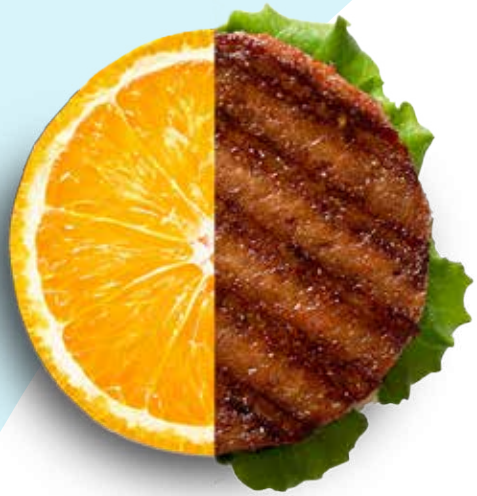

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The importance of food science, as it applies to food and beverage product development, is more relevant than ever as consumer demand for healthful, flavorful, high-protein foods continues to rise.

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Global Innovation Trends Driving Proteins

TOM VIERHILE, MBA, VP STRATEGIC INSIGHTS, North America, Innova Market Insights, provided fascinating statistics and cutting-edge examples highlighting recent trends in new food products containing plant-based protein ingredients. His presentation titled "The Rise & Rise of Proteins: Global Consumer and Innovation Trends Driving Proteins to New Heights" was given at the 2022 Protein Trends & Technologies Seminar.

Innova Market Insights is a Netherlands-based market research company that compiles information on a dizzying array of new packaged food products each year. It is well-known for its annual "Top Ten Trends" list generated from this data. Innova's Trend #2 for 2022, "Plant-based: The canvas for innovation," was a focus of his talk, which highlighted the intersection and synergism of this trend with other current trends, including sustainability, environmental impact, "upcycling" (using food processing byproducts as ingredients) and "tech to table" (Innova's Trend #3 for 2022).

One in four American consumers increased their consumption of protein in the past year, with its association with health benefits the main driver of this growth. In line with this consumer data, Vierhile presented data demonstrating a steady increase in the introduction of new food products with marketing claims related to protein content (such as "high in protein").

Plant-Based Protein Gains Ground

While Americans consume more meat than a year ago, plant-based proteins also exhibit impressive gains. The percentage of new products containing plant-based products has risen from 17 to 24% in just four years, and more than twice as many consumers reported they increased vs. decreased consumption of plant-based products last year. Consumers trust that plant-based proteins are healthier and better for the planet, with a third of U.S. consumers believing in the future of plant-based foods. However, 55% of U.S. consumers still prefer meat and dairy over plant-based proteins, and 42% of consumers find the taste or texture of plant-based meat and dairy alternatives inferior to that of the "real" products, leaving significant room for improvement.

Plant-based protein food products are priced higher than the foods they are trying to replace. However, about half of consumers globally reported they would pay more for plant-based alternatives if they came with added health benefits.

Vierhile described some of the latest trends Innova has observed for plant-based protein products. While U.S. companies are moving away from old standbys, such as wheat and soy, new proteins, like chickpeas and fava beans, are quickly gaining ground, with pea protein remaining "on trend." Innovative plant-based proteins used in meat and dairy substitutes are now finding their way into snacks and other indulgence products. Unusual plant-based protein ingredients, such as nutritional fungi and cacao fruit, are being explored. In some cases (as in a new European infant formula), plant and animal ingredients are used in the same product.

Upcycling is Up

Upcycled ingredients are also gaining momentum in new food products, with 40% of global consumers finding products with upcycled ingredients more appealing than other products (but also believing they should cost less). Vierhile highlighted upcycled sesame milk made from the byproducts of sesame oil production as an example of an upcycled ingredient now in use. A bonus for this ingredient is the sustainability of the sesame crops: Sesame growth requires very little water (eight times less than almonds), and the plant is self-pollinating and therefore doesn't require bees.

"Tech to table" is another top trend Innova identified in 2022 that is closely linked to the plant-based movement. This trend includes novel processing technologies, such as precision fermentation, cultured meat, vertical farming and more. In the U.S., 48% of consumers say they would accept products in this category, with higher percentages noted in regions outside of the U.S. Healthiness was reported to be a primary driver toward acceptance of new technologies. In addition, more than a third of consumers view new technologies related to producing meat and dairy alternatives as more sustainable.

In the future, Vierhile predicts that the development of bioidentical, lab-cultivated proteins will accelerate, while clean label and "free from" claims will become more important. He is confident that the use of plant-based protein ingredients will continue to grow, while remaining equally confident that animal-based proteins will remain a staple in the diet of many Americans.

"The Rise & Rise of Proteins: Global Consumer and Innovation Trends Driving Proteins to New Heights," Tom Vierhile, MBA, VP Strategic Insights, North America, Innova Market Insights

Innova's #2 and #3 2022 Top Trends Have Strong Synergies

2. Plant-Based: The Canvas for Innovation
Nutrition and sustainability play a bigger role as brands refine the next generation of plant-based foods.

3. Tech to Table
Technological advances have created serious innovation opportunities for the entire food and beverage industry.

SOURCE: TOM VIERHILE, INNOVA MARKET INSIGHTS/2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

Consumer demand for plant-based foods that deliver taste, texture, health and sustainability increases the need for more advanced ingredients and formulation strategies.

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Legal Complexities of Labeling Protein-Based Foods

DRAWING UPON HER WEALTH OF EXPERIENCE at the FDA and as a practicing attorney, Jessica P. O'Connell, Partner, Covington & Burling, presented practical information to help food companies understand the legal complexities associated with labeling protein-based foods. Focusing on protein-based foods, she summarized recent litigation concerning labeling claims and provided insights into regulatory and legal changes expected in the future. Her presentation titled "From Standards of Identity to Sustainability Claims: Hot Topics in Protein-Based Foods" was given at Global Food Forums' 2022 Protein Trends & Technologies Seminar.

Regulatory Review

Beginning with regulatory background, O'Connell discussed the information for which a marketer is responsible. The FDA, the Federal Trade Commission and various state laws regulate labeling and advertising. In addition to the label itself, information on websites, advertisements, social media, press statements and endorser claims are subject to legal risk. Labels and labeling must be truthful and not misleading; advertising cannot deceive consumers.

Companies are responsible for "substantiating the net impression of every reasonable consumer." A reasonable consumer is generally considered an uneducated consumer, but the judge defines a "reasonable consumer" during litigation. O'Connell provided examples of similar cases that resulted in different outcomes based on each judge's definition of "reasonable consumer." Potential risks related to labeling and advertising facing companies include actions by FDA (warning letters), FTC (consent orders), state attorneys general, and competitor and consumer challenges, including class action lawsuits.

FDA labeling regulations require packaged foods to bear a statement of identity, which may be tied to a standard of identity (SOI) for some foods. The common or usual name of a food should be used in labeling, and it should be specific enough that consumers will know what it is without being confused.

As a color additive, soy leghemoglobin required the FDA to establish the name. Their naming considerations for this product represent a useful case study and model for naming new ingredients. (See sidebar "Case Study: Soy Leghemoglobin.")

Within the dairy space, FDA has established SOIs for numerous products. The SOI for milk states that it is "the lacteal secretion… obtained by the complete milking of…cows." This would seem to preclude plant-based products from calling themselves "milk," a position seemingly solidified when former FDA commissioner Scott Gottlieb famously declared, "an almond doesn't lactate." However, established products like goat milk do not meet the SOI, yet they have used the term "milk" in their name for many years. As a result of this lack of resolution, O'Connell expects that the topic of dairy SOIs will re-emerge as a topic for FDA consideration in the coming years.

In the meat area, USDA has stated that it will be addressing naming for cultured meat products via a former rulemaking process. At the state level, some 27 states have introduced laws prohibiting alternative meat substitutes from using the term "meat" in labeling. However, litigation in this area has already resulted in some of these laws being struck down.

Where is Litigation Occurring?

The mechanisms that police food claims have changed significantly in the last decade. A steep decline in the number of Warning Letters issued by the FDA for food claims occurred between 2009 and 2021, with 34 warning letters issued in 2010 vs. only six in 2021. By contrast, the number of food claim class action lawsuits jumped from 26 in 2009 to 325 in 2021. According to O'Connell, this is where risks lie.

Where is this litigation occurring? The dairy space has been the subject of considerable litigation, with courts finding that terms such as "almond milk" and "cultured vegan butter" are not deceptive. Such wins for plant-based products, however, required expensive, time-consuming litigation. Other food claim areas subject to recent litigation have included protein calculations in plant-based products, sustainability claims and animal welfare claims.

O'Connell concluded by outlining what to expect soon for standards of identity and food claims. FDA may address (and potentially

Case Study: Soy Leghemoglobin

- FDA denied the Center for Food Safety's (CFS) objections to the color additive approval for soy leghemoglobin in December 2019.
- CFS filed six objections, including one stating that FDA should require the ingredient to be labeled "soy leghemoglobin/*P[ichia] pastoris* yeast protein" to notify consumers who "believe that they have allergies to either soy products or yeast products."
- In response, FDA maintains that:
  - While the color additive soy leghemoglobin contains residual amounts of *P. pastoris* yeast protein, in addition to the principal coloring component soy leghemoglobin protein, "the totality of evidence presented in the color additive petition indicated that there is a reasonable certainty that soy leghemoglobin protein and *P. pastoris* yeast proteins do not pose any unique allergenicity risks."
  - "Because soybeans are identified as a major food allergen, foods that contain soy leghemoglobin must be labeled accordingly. Yeast protein has not been identified as a major food allergen."

SOURCE: JESSICA P. O'CONNELL, PARTNER, COVINGTON & BURLING/2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

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modify) standards of identities for dairy products. USDA will be developing a federal framework for naming cultured protein products. Ongoing state litigation for alternative protein names is likely, and class action lawsuits regarding naming and claims related to sustainability, nutritional benefits and animal benefits of foods are expected.

"From Standards of Identity to Sustainability Claims: Hot Topics in Protein-Based Foods," Jessica P. O'Connell, Partner, Covington & Burling [See the PowerPoint PDF at https://foodproteins.globalfoodforums.com/food-protein-rd-academy/hot-topics-in-protein-based-food-labeling-presentation/]

Blending, Processing Improves Protein Quality & Claims

"PROTEIN QUALITY IS GENERALLY ASSESSED as a function of its ability to meet the biological needs of the consumer," explained Matthew Nosworthy, Ph.D., Food Science and Nutrition Research Scientist with Guelph Research and Development Centre, Agriculture and Agri-food Canada. His topic, "Enabling Protein Claims & Improved Protein Quality Through Blending & Processing Protein Ingredients," was presented at the 2022 Protein Trends & Technologies Seminar.

Aspects of protein quality include sustainability, functionality, color, taste, health profile, cost and—the focus of this talk—nutritional quality. "The nutritional quality of a protein is important for consumers to assess how 'good' it is for them," noted Nosworthy. "For commercial manufacturers, it is important for ingredient selection and package labeling."

Assessing Protein Quality

"Methods for protein quality in Canada and the U.S. are determined by the protein efficiency ratio (PER) and protein digestibility-corrected amino acid score (PDCAAS), respectively," explained Nosworthy. Released in 2013 by the Food and Agricultural Organization in conjunction with the World Health Organization, the digestible indispensable amino acid score (DIAAS) is a novel approach to measuring protein quality. Still, it is not currently used as a regulatory method. PDCAAS assesses nitrogen digestibility rather than amino acid digestibility used in DIAAS.

The PDCAAS is determined from the product of the AAS (calculated by dividing the food AA by the AA in the reference pattern, taking into account the lowest AA) and True Fecal Protein Digestibility (TFPD, determined by fecal nitrogen output divided by the dietary nitrogen input), with a correction for endogenous losses.

Values are truncated at 1.00, so proteins of higher quality are not identified, and the quality of any blend may be inaccurate if truncation is required.

Nosworthy explained that "there are ways that PDCAAS data can be misrepresented. Variables include how the amino acid composition was determined and which reference pattern was used for the calculation of the AAS." For the latter, the year of publication and the age range used can impact the PDCAAS. For protein digestibility, modeling with an animal or human study or *in vitro* (i.e., bench-top assessments) testing can yield different results.

Improving protein quality by blending is important in dietary planning and interventions, and for ingredient selection related to quality for package labeling. Nosworthy described research that found a correlation between both digestibility and PDCAAS values generated from *in vitro* and *in vivo* methods. (Nosworthy, MG, House JD. *Cereal Chem.* 2017/ http://bit.ly/316GlTc). There is an increasing desire to reduce animal experimentation to determine protein quality.

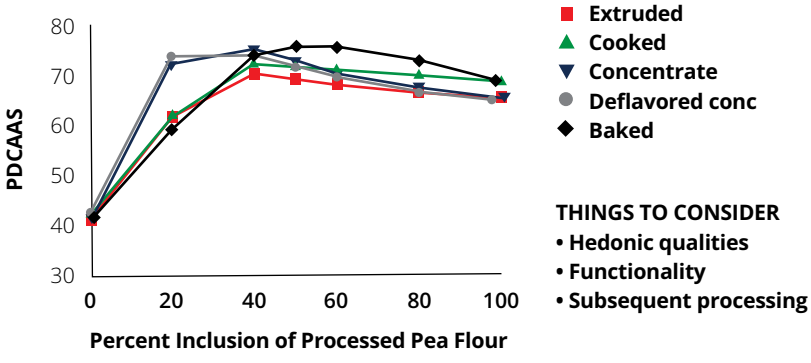
The blending of 50:50 of extruded buckwheat with pinto resulted in higher protein efficiency ratio values; increased digestibility; and greater PDCAAS (Nosworthy et al. *J. Agric. Food Chem.* 2017/ https://bit.ly/2RgcSGF).

Another study showed that the PDCAAS for processed beans was higher than the DIAAS (61 vs. 45%). Extrusion and/or cooking of various beans resulted in higher PDCAAS (66% average) and DIAAS values (61% average) than baked (52 and 48%). A significant correlation was found between PDCAAS and *in vitro* PDCAAS (R2 = 0.7497). (Nosworthy, MG et al. *Nutrients.* 2018/ http://bit.ly/2IyzoUw)

Pulse Inclusion

The blending of wheat flour with increasing pulse inclusion will increase PDCAAS values from 0.39 to upwards of 0.80, supporting how blends can be designed to maximize quality. (See chart "Modelling PDCAAS of a Wheat/Pea Flour Blend.")

Modeling PDCAAS of a Wheat/Pea Flour Blend



SOURCE: NOSWORTHY, MG, UNPUBLISHED/2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

The blending of wheat flour with increasing pulse inclusion will increase PDCAAS values from about .4 to almost 0.80, supporting how blends can be designed to maximize quality.

Nosworthy also presented processing data using pulses that showed dramatic effects on PDCAAS values following cooking, baking and extrusion; enzymatic hydrolysis using different proteases; and fermentation with various microorganisms, times of exposure, and solid-state vs. liquid conditions.

Protein content claims for foods are based on the product of the PDCAAS and the protein content of the representative amount customarily consumed (RACC)—which means the serving size can affect the protein claim. For example, sunflower seeds with a PDCAAS of 0.66 but a RACC value of only 30 result in a Corrected Protein Content in RACC (g) of 4.1, and no claim is permitted. In contrast, whole green lentils with a PDCAAS of 0.63 and a RACC of 35 have a Corrected Protein Content in RACC of 5.8. In this case, a "Good Source of Protein" claim is permitted.

PDCAAS of greater than 0.20 is considered a "significant source of protein" for all non-infant foods; for DIAAS, the cut-off is greater than 75. Nosworthy stated that "a value of 5 to 9.9g is a 'good source' of protein; 10g or greater is an 'excellent source.'"

The limitations of plant proteins include allergenicity (including those from peas) and secure supply chains (e.g., rice, pumpkin seed, microalgae). Compositional challenges include low protein content (cereals) and anti-nutritional factors that reduce digestibility, such as protease inhibitors, tannins, phenolics and phytate. "Challenges also include limiting AA in cereals that include lysine, leucine in ancient grains, and methionine, cysteine and tryptophan in pulses," Nosworthy said.

"Protein quality claim assessment is complex, with different protein sources possessing their unique challenges," summarized Nosworthy. "Blends can be designed theoretically to maximize quality; selecting an appropriate processing method is critical."

"Enabling Protein Claims & Improved Protein Quality Through Blending & Processing Protein Ingredients," Matthew Nosworthy, Ph.D., Food Science and Nutrition Research Scientist with Guelph Research and Development Centre, Agriculture and Agri-food Canada [To access the presentation PDF, see https://foodproteins.globalfoodforums.com/food-protein-rd-academy/improved-protein-quality-through-blending-processing-presentation/]

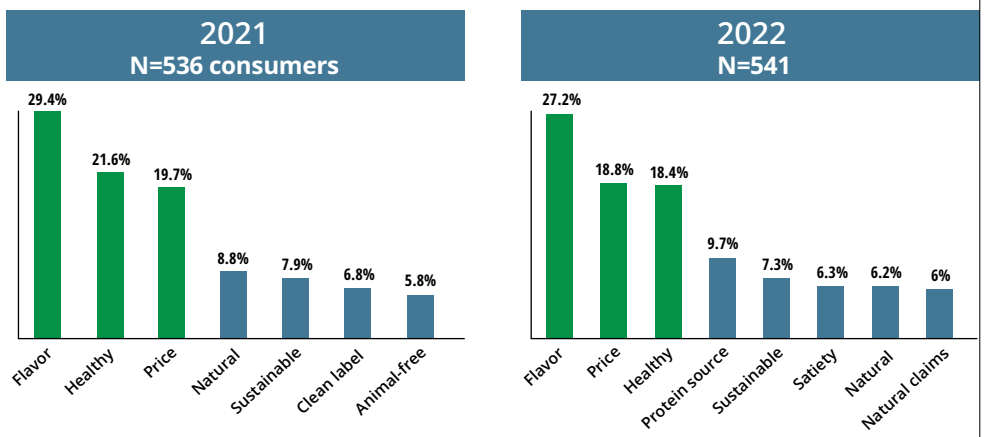
Consumers and Protein Products: Flavor Still Rules

"WHILE U.S. CONSUMERS ARE FOCUSED ON healthy eating, they are often misinformed about protein," said MaryAnne Drake,

Director of the Sensory Service Center at North Carolina State University. Drake made this point during her presentation, "Consumers and the Protein Product Explosion: Flavor Still Rules," at the 2022 Protein Trends & Technologies Seminar.

There has been a massive rise in the purchase and consumption of plant-based alternatives and, at the same time, the consumption of dairy products is at an all-time high—one not seen since the 1950s. Additionally, plant-based protein sources have exploded, and animal-free or precision-fermentation protein products have recently appeared on the market. Both types imply a sustainable, ethical or healthy alternative.

Flavor, Price and Health Rule



SOURCE: DRAKE, M, SURVEYS CONDUCTED IN 2021 AND 2021, NORTH CAROLINA STATE UNIVERSITY/2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR
NOTE: CHIP ALLOCATION QUESTIONS: AVERAGES ARE BASED OFF A TOTAL SUM OF 100% FOR THE COMBINED ATTRIBUTES.

A 2022 survey found that "flavor" is still the most important attribute for consumers, and "price" came in second place. In the 2021 survey, "healthy" occupied second place.

Drake's group surveys consumer insights on protein choices. In 2018, consumer focus was on the total amount of protein per serving, with a clear preference for whey protein over plant protein. In 2020, consumers expressed interest in "good source, "complete protein" and "flavor" and found plant-based protein more desirable than dairy protein.

In an August 2022 survey, key protein attributes investigated were "good source of protein," "tastes great," "healthy" and "complete protein." The type of protein, plant vs. dairy, decreased slightly in importance.

Sustainability Growth

Although dairy protein still leads the market, pressure for sustainability continues to build. Yet, there needs to be more consumer knowledge. For example, agriculture contributes only 10% to U.S. greenhouse emissions, but consumers think it contributes 24%.

The CFR defines sustainability, but it is a very gray area for consumers. Packaging, animal welfare, environmental impacts and simple/minimal ingredients all affect the perception of sustainability. Plant sources are universally perceived as more sustainable than animal.

Soy/pea is perceived as more sustainable than almond, coconut or dairy. Drake said plant protein powders are considered more sustainable than almond or dairy.

Interest in food sustainability is strong among Millennials and Gen Zs, while older consumers have a better understanding of dairy products and proteins. Most consumers need to gain more knowledge of animal-free protein. "Precision fermentation" or "cell-cultured" are more favorable terms than "animal-free" or "gene-edited," Drake explained.

Some consumers believe that "good source of protein" is a marketing term. They also don't know what "complete protein" means. However, complete protein is a valuable indicator for dairy protein once consumers are educated on the definition. Adding a processing term, such as pasteurized or ultrafiltered, decreases consumer confidence. Even adding the word "concentrate" or "isolate" to a pea protein makes consumers think it is less natural. We can positively influence consumers with a small factoid of information, Drake advised.

Protein Flavor

All proteins have flavor, and off-flavors are present in all protein types. Within a given protein type, there is much variability in flavor. Additionally, protein flavor changes over time. Generally, the more protein you put into a product, the more issues you will have with protein flavor.

In one study, a trained panel in Drake's lab tasted 10 samples of whey protein from different protein suppliers and found they all tasted different. The same was true for pea proteins. The panel also found that soy, milk, whey, potato and pea protein had a unique flavor profile.

Plant proteins have a wider array of flavors; some are easier to mask than others. As one increases the amount of protein, the intensity of flavors increases. In comparison, protein beverages made with blander whey proteins were preferred by consumers. When ready-to-mix (RTM) protein powders were rehydrated, the "liking" of those made with plant proteins was not equivalent to the liking of those made with dairy protein.

Using principal component analysis and projective mapping, plant-based yogurts didn't taste anything like dairy yogurt. Similar results were found with plant-based cream cheese and other plant-based cheeses.

While flavor rules, texture and functionality are also critical for consumer experience. Texture is challenging for plant-based cheese, as is smoothness, melt and heat stability. (See chart "Flavor, Price and Health Rule.")

For plant proteins, the opportunities include consumer desire for more plant-based products and increased pressure for sustainability. The challenges include issues with flavor, texture and consumer perception.

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Dairy's opportunities include great taste and nutrition, plus a clean label. Many consumers are uneducated about the health benefits of dairy, including that it is a complete protein. Consumers are also misinformed about sustainable agriculture and the dairy industry.

"Consumers and the Protein Product Explosion: Flavor Still Rules," MaryAnne Drake, Ph.D., Sensory Analysis and Flavor Chemistry, William Neal Reynolds Distinguished Professor, North Carolina State University

Plant-Based Proteins' Functional Properties & Processing

COMBINING TECHNICAL AND INDUSTRIAL EXPERIENCE, Emma Laing, MSc, Program Facilitator, Saskatchewan Food Industry Development Centre, provided an overview of plant-based protein ingredients. Her presentation, "Plant-Based Proteins' Functional Properties & Processing Technologies," was given at the 2022 Protein Trends & Technologies Seminar. The Saskatchewan Food Industry Development Centre is a non-profit that provides innovation and support for the agri-food sector in Canada.

Laing covered sources of plant protein ingredients, functional properties associated with plant-based proteins and the effects processing technologies have on these proteins. She noted that the term "plant-based" was coined by T. Colin Campbell in 1980 to describe a vegetable-based diet he promoted as a cancer treatment strategy. Campbell used plant-based to describe the diet objectively and avoid the highly charged emotions evoked by terms such as "vegan" or "strict vegetarian."

The term plant-based started to become widely used in about 2004. Although at first it was commonly associated with meat substitutes, plant-based is now widely used for many products, from dairy products to cosmetics to even hand sanitizer.

Many types of consumers are now embracing foods with high protein content and, as a result, many of the Centre's client companies want to make food products that are high in protein. The value propositions of products with plant-based protein ingredients include those related to nutrition and those with advantages related to labeling, sustainability, functionality and replacement of non-clean-label, expensive or allergenic ingredients.

SOURCES AND PROCESSING PLANT PROTEINS

Laing said plant protein ingredients come from various sources (pulses, legumes, oilseeds, cereals) and can be categorized based on their protein content. For example, flours generally contain 3-18% protein, while high-protein flours contain 18-50%. Protein concentrates are often set at 50-80%, and protein isolates contain greater than 80%.

Processing plant proteins is complicated. Every plant protein is processed differently, and there are multiple ways to process a single protein. In some cases, plants are processed initially for other purposes (e.g., the processing of oil from oilseeds) where the protein fraction is considered a co-product. In pulse processing, protein is the primary ingredient of interest, but it only comprises 20-30% of the seed. Starch and fiber, which comprise the majority (50-60%) of pulse seeds, are co-products, and processors are actively trying to use these components to add value.

Unique plant protein processing technologies can be implemented in the field (using variety-specific methods, harvesting technology, storage and transport); during seed or grain processing (cleaning, germination, heat treatments, soaking, tempering, grinding, milling); during ingredient processing (fermentation, heat treatment, extrusion, gelatinization); and consumer product manufacturing (formulation, blending, solubilization, etc.). These technologies can affect quality, functionality, ease of use, nutrition and taste—but might add cost to implement in production, Laing said. Because plant protein processing is a relatively new and rapidly growing field, she added that very little of this research is published, to protect intellectual property.

Uses for Plant Protein Concentrates

Plant protein concentrates and isolates can be incorporated into many food types. Concentrates are typically included as 10-30% of a food product. While lower levels are used in beverages due to sensory impacts, higher levels are possible in products such as pasta

Plant Protein Value Propositions

Labeling & Sustainability	Functionality	Nutrition	Replacement
Natural	Water binding	PDCAAS	Allergen replacement
Non-GMO	Water holding	DIAAS	Cost reduction
Gluten-free	Oil binding	High in lysine	Differentiation
Allergen-free	Solubility	High in sulfur-rich amino acids	
Sustainability	Dispersibility	High in tryptophan	
Carbon footprint	Emulsification	Complete protein	
Traceability	Texture		
	Binder		
	Gelation		
	Adhesion		
	Sensory attributes		

SOURCE: EMMA LAING, SASKATCHEWAN FOOD INDUSTRY DEVELOPMENT/2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

Plant-based proteins provide foods and beverages with value-added functional, nutritional and sustainable properties.

or where plant protein concentrates or isolates can boost the protein content to about 17-18%.

Plant protein concentrates can enhance end-user functionality and alter the properties of a food product in a wide variety of ways, depending on the application. They include increasing water and oil absorption; as well as enhancing emulsion capacity, "whipability"/ foamability, texture, viscosity and, (most importantly to consumers), enhanced taste and flavor. This functionality is greatly affected by how the plant protein is processed.

Understanding protein selection and functionality can shorten development time; ensure product stability throughout shelflife; as well as provide consistency, save money and aid in scale-up efficiency. Furthermore, this knowledge can optimize the choice of ingredient processing technologies and offer the opportunity to use unique functions to create novel food products, Laing advised.

"Plant-Based Proteins' Functional Properties & Processing Technologies," Emma Laing, MSc, Program Facilitator, Saskatchewan Food Industry Development [To access the presentation PDF, see https://foodproteins.globalfoodforums.com/food-protein-rd-academy/functionalities-and-processing-effects-of-plant-based-proteins-presentation/]

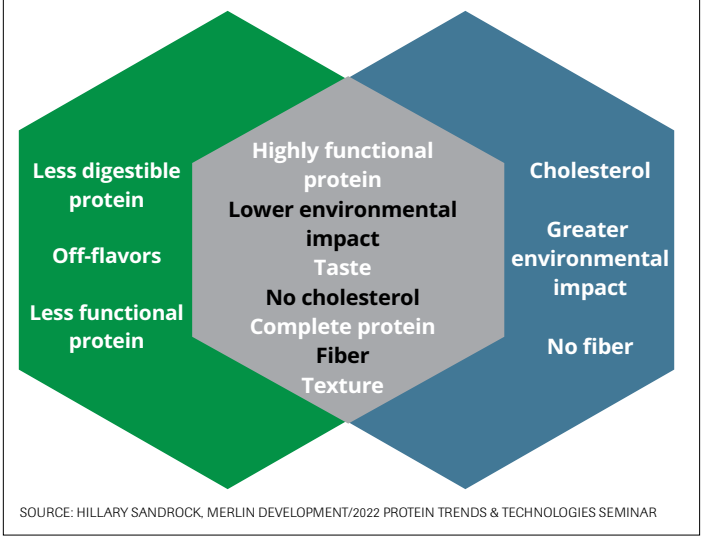
Combining Dairy and Plant Proteins

PLANT-BASED PRODUCTS are often positioned as replacements for their dairy competitors. However, "What if, rather than having to choose one or the other, you could get the benefits of both in one?" asked Hillary Sandrock, Senior Scientist with Merlin Development. Sandrock posed the question during her presentation, "The Best of Both Worlds: Combining Dairy and Plant Proteins in Cultured Products," given at Global Food Forums' 2022 Protein Trends & Technologies Seminar.

Yogurt starts with milk, a natural product with a PDCAAS of 1.00 and a DIAAS of 1.14. Yogurt production involves blending, pasteurizing, homogenization and fermentation. Yogurt cultures feed on lactose and produce lactic acid, which drops the pH to 4.6, where casein aggregates and forms a gel network.

To make plant-based yogurt, start with plant protein, which can come from various sources, including legumes, cereals and nuts. Plant proteins tend to have a globular structure, like whey. They are generally less digestible and have lower solubility than dairy proteins, and they possess characteristic plant protein flavors, Sandrock explained.

Benefits of Combining Dairy and Plants



SOURCE: HILLARY SANDROCK, MERLIN DEVELOPMENT/2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

Plant-based and dairy yogurt each have their advantages and disadvantages. Combining dairy and plant proteins can achieve a highly functional protein blend with a lower environmental impact, good taste, no cholesterol, complete protein, a fiber claim and good texture.

Creating Plant-Based Milk Products

Creating plant milk could involve hydrating a protein powder or soaking, grinding and milling a nut. Fats and oils are added to produce the desired fat content, and a carbohydrate source, such as glucose or sucrose, is added. Starches and gums are used to stabilize and provide thickening and texture. Culture times are generally longer. The finished product often has a higher solids nonfat (SNF) level.

Plant source candidates for yogurt include those in the top-selling plant-based milks—almond, oat, soy and coconut. Coconut is a popular yogurt base, but coconut yogurts contain less than 1% protein compared to 3 to 5 % protein for dairy yogurt, Sandrock pointed out.

Soy has a PDCAAS of 0.98 and a DIAAS of 0.90; is relatively neutral in color; and has some gelling properties. However, soy is a major allergen known for its beany flavor and astringency in acid conditions.

Oats contain 10 to 15% protein and are high in soluble fiber. Their beta-glucans and starches contribute to a slimy texture in yogurt. To reach a target protein level, combine oat with chickpea, advised Sandrock. Chickpea is a legume like soy but with less protein. Chickpeas are not a major allergen, contribute fiber and have natural emulsifying properties. However, they too can contribute off-flavors.

Almonds have a sweet, nutty flavor and good gelling properties. They are also a significant allergen. Almonds have a PDCAAS of 0.29 and a DIAAS of 0.40. They contribute healthy fat and generally produce a higher fat yogurt.

Why Not More Plant-based Yogurt Consumption?

The number one reason people don't choose plant-based yogurt is because of its taste. High cost is also a concern, as is texture.

Does it make sense to combine plant-based and dairy yogurts? We have seen a lot of growth in plant-based yogurt sales in the last few years, but it's a small fraction of the dairy yogurt market. Sandrock noted that about half of U.S. consumers embrace the flexitarian lifestyle, while only 6% identify as vegetarian or vegan. However, nine out of 10 consumers of dairy alternatives also eat real dairy.

At Merlin Development, a sensory panel compared yogurts of varying dairy- and plant-based protein blends. They chose four different retail plain yogurts—dairy, almond, soy and an oat/chickpea base—and compared their sensory attributes, appearance and overall liking at different blended ratios.

- ALMOND: Blends with higher levels of almond yogurt were beiger in color, thicker and had a higher viscosity. Almond-based yogurts were quite sweet with increased nuttiness.
- SOY: Lower levels of soy in dairy/soy blends scored remarkably similar to all-dairy yogurt in most attributes except the color. Blending soy into dairy also created increased chalkiness and "beaniness."
- OAT/CHICKPEA: In the oat/chickpea blends, chalkiness increased with percent of plant-based yogurt. The cereal and cardboard notes were more prevalent in these blends at higher blend levels.

A compilation of results from scientific journals revealed that plant yogurts generally scored below five on a nine-point Hedonic scale in texture, flavor and overall liking. Some 53% of consumers said that taste is a significant barrier to eating plant-based yogurt. Merlin Development panelists saw similar trends. Except for almond, all 100% plant-based yogurts were disliked. Various blends of dairy- and plant-based yogurts achieved acceptable liking scores.

When comparing the nutritional values of the various blends, all samples had similar protein levels, comparable to dairy yogurt. Carb levels were higher with all the dairy/plant blends. The almond yogurt blends had a considerable spike in fat, but saturated fat was less than dairy-based yogurts. There is no fiber in dairy, but all blended yogurts achieved a fiber claim.

"The Best of Both Worlds: Combining Dairy and Plant Proteins in Cultured Products," Hillary Sandrock, CFS, Product Development Food Scientist, Merlin Development, Inc. [A very abbreviated presentation pdf can be accessed at https://foodproteins.globalfoodforums.com/food-protein-rd-academy/dairy-and-plant-proteins-in-cultured-products-presentation/]

Benefits Derived from Dairy Protein Ingredients

"DAIRY PROTEINS ARE CONCENTRATED, isolated or hydrolyzed to produce a wide variety of ingredients that perform well to deliver taste, nutrition and functionality for a wide variety of food applications," conveyed Phillip S. Tong, Ph.D., Professor Emeritus,

Domestic whey protein isolate use reportedly increased 22% in 2020—sports bars being the primary reason for this growth.

California Polytechnic State University San Luis Obispo. In his presentation, "Dairy Protein Ingredients Deliver Benefits for Consumers and Product Development," at Global Food Forums' 2022 Protein Trends & Technologies Seminar, Tong pointed out that dairy proteins are manufactured and used worldwide, as many benefits are derived from dairy protein ingredients.

Whey is the fluid that is a co-product of cheese manufacturing. Sweet whey is derived from the manufacture of rennet hard cheeses, whereas acid whey comes from the manufacture of acid products, such as cottage cheese or Greek yogurt.

"Caseins are phosphoproteins that make up 80% of the proteins in cow's milk. Whey proteins make up the remaining 20% of milk proteins. Caseins are insoluble at pH 4.6 at 20°C, whereas whey proteins are soluble at the same pH. Other, newer dairy protein ingredients include lactoferrin, a biologically active milk protein; bovine alpha-lactalbumin; and micellar casein, an ingredient produced using microfiltration that alters the casein-to-whey protein ratio compared to that found in milk," explained Tong.

Dairy Protein Benefits

Research supports dairy protein benefits in human health, such as helping to manage blood glucose and blood pressure; reducing cardiometabolic risk factors; providing strength during the aging process; and promoting a robust immune system. Dairy proteins have more essential amino acids as a percentage of protein compared to plant-based proteins, such as soy and pea, and dairy proteins are more digestible than plant-based proteins.

"Food proteins vary in their protein quality, based on amino acid composition, digestibility (over 90% for animal-based proteins vs. 45-80% for plant-based proteins) and bioavailability. PDCAAS, the current gold standard used in assessing protein quality, and DIAAS, which accounts for differences in individual amino acid digestibility, are used to measure protein quality. Dairy proteins rank at the top of the list," explained Tong. (Data adapted from JMathai, JK, et al., *Brit J Nutr.* 2017/ http://bit.ly/3WS5n5h [Table 6].)

"Dairy proteins also have high concentrations of the amino acid leucine, which is believed to be an independent predictor of the protein's capacity to stimulate postprandial muscle protein synthesis," Tong added.

Milk proteins are also known to enhance sleep, because they contain tryptophan and serotonin, which stimulate the release of melatonin. Health and wellness benefits of good sleep, especially when using dairy proteins, are well-known and include improved blood pressure control, muscle building, weight loss, improved mental function and enhanced energy levels, noted Tong.

Diary Functional Properties

"Dairy proteins have exceptional functional properties that can be modified and enhanced through further processing into ingredients, such as milk- and whey-protein concentrates and isolates. Whey proteins can enhance whipping and foaming; they are soluble over a wide range of pH values, allowing their use in various food products and systems; and they can enhance gelation. Caseins, which are soluble at neutral pH, can be used for foaming, water binding and fat emulsification. And, of course, both can be used for flavor development, food fortification and enhancing the overall appearance of a food," expressed Tong.

Consumer demand for products containing dairy-based ingredients has resulted in a steady increase in the use of dairy proteins—supported by over 30 years of data. For example, in 2015, there were 7,861 new products using dairy proteins. This number rose to 9,413 in 2020, reflecting a 19.7% increase, according to the U.S. Dairy Export Council.

Tong provided data on the primary food industry segments using whey protein concentrate, which included sports powders, followed by dairy foods, mainstream nutritional products and prepared dry mixes. Segments using whey protein isolate were led by sports bars, then prepared dry mixes, sports powders and sports beverages. Whey protein use has also increased from 2015 to 2020 in bakery items, snacks and desserts, and ice cream, per the U.S. Dairy Export Council.

The potential health benefits derived from dairy proteins, plus their exceptional functionality, have contributed to the steady growth of products using these ingredients worldwide in all types of product categories. This trend has continued for 30-plus years and does not appear to be fading, concluded Tong.

"Dairy Protein Ingredients Deliver Benefits for Consumers and Product Development," Phillip S. Tong, Ph.D., Professor Emeritus, Cal Poly State University San Luis Obispo [See the presentation at https://foodproteins.globalfoodforums.com/food-protein-rd-academy/dairy-protein-ingredient-technology-presentation/]

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Regulatory Approval of Novel Protein Ingredients

"THE U.S. IS ONE OF THE FEW jurisdictions that regulates new food ingredients as food additives unless the substance is concluded Generally Recognized as Safe (GRAS) among scientific experts," stated Ray Matulka, Ph.D., Director of Toxicology, Burdock Group Consultants. In his presentation, "Novel-Sourced Protein Ingredients: Critical Scientific Components for Regulatory Compliance," at Global Food Forums' 2022 Protein Trends & Technologies Seminar, Matulka expanded on the rigorous criteria required in securing regulatory approval of novel-sourced protein ingredients.

A food additive regulation or GRAS status is based on the intended conditions of use, not the ingredient itself. For example, Matulka noted that "the dose is the poison." An amino acid may be safe at specific use levels, but a novel source could introduce toxic contaminants that would be an issue when the ingredient is used at a higher level.

It is best to meet with FDA initially to determine a roadmap to approval. But many companies want to rush their product to market ASAP, waiting until the last step for approval, said Matulka.

Completing a Dossier for GRAS

Matulka described the information required when completing a dossier for GRAS for new protein ingredients. Identification, specifications and manufacturing methods for the component must be detailed. Potential contaminants must be identified, and stability, safety and consumption patterns must be presented. Additionally, claims must be substantiated, and proper labeling with intended use must be provided.

Studies to Support Conclusion of Safety

- **Repeat-dose/dietary toxicity study in rodents**
  - o Conducted according to FDA/OECD protocol—typically 90 days in length
  - o 14-day palatability study prior to the main study
  - o Safety-related endpoint parameters should be included
  - o Test substance should meet commercial specifications
- **Genotoxicity studies**
  - o Typically, both *in vitro* and *in vivo* genotoxicity studies
  - o Conducted according to FDA/OECD protocols
- **Assessment of potential allergens may be necessary**
  - o Human tolerability studies
  - o Quantitative risk assessments for potential allergenicity
  - o Adverse-event reports on similar products or components

SOURCE: RAY MATULKA, PH.D., DIRECTOR OF TOXICOLOGY, BURDOCK GROUP CONSULTANTS/2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

To complete an FDA dossier, one must conduct research to support GRAS determination.

"One of the biggest data challenges posed by the FDA is not only the source, but modifications and chemical changes to the raw ingredient," explained Matulka. In addition, "the manufacturing process, safe use of technical additives and processing under current Good Manufacturing Practice (cGMP) standards" are all critical to GRAS assessments.

Represent the Whole Ingredient

The manufacturer must demonstrate a complete understanding of the whole ingredient, not just the "active" components. All components of the final ingredient—"to nearly 100%"—must be understood. Also, the company must be able to describe the component within the raw material that explains why the novel ingredient should be added to food.

Stability data under typical storage conditions are required for the ingredient when isolated and used in food/feed. "Does the oil content of a protein obtained from an oilseed introduce rancidity?" posed Matulka. "If so, will an antioxidant be needed, especially if high protein levels will be utilized in a product?"

Proteins contained in ingredients that can be supported through a history of safe use, such as soy, oat or almonds, are good candidates for GRAS. While introducing novel ingredients is important, some new sources may have antinutrients that could present a nutrient absorption issue, so processing for safe use is essential.

Defining the traits of source organisms is a critical part of a regulatory evaluation, such as whether the ingredient is microbe- or enzyme-based; whether the production organism is native or genetically modified; whether there will be up-regulation or deletion of native genes in the source organism; and whether the production microbe will be viable in the finished product, noted Matulka.

Genetically engineered proteins may yield potential allergens. Variables to consider are the gene source, amino acid sequence of the protein and the stability of the protein to digestion.

"Fermentation may result in metabolites that may not be safe for humans or animals," explained Matulka. FDA expects a thorough safety assessment. All media components must also be "food grade" and "safe and suitable" for the intended use.

The FDA is very concerned with the amount of a consumed ingredient that may be used as a sole food in a diet, such as high-protein shakes. Other key questions include if the protein-based ingredient amino acids enter the bloodstream intact; whether the ingredient will replace other nutrients or increase some nutrients over others; and whether ingredient consumption could lead to imbalances in amino acids.

Claims substantiation must include literature-based documentation of the mechanism of action and clinical trials with statistically significant outcomes from a control group. Moreover, "structure or function of the body" statements must be based on nutritive value.

Matulka concluded with a summary of four key takeaways FDA requires for GRAS:

• Naturally sourced isolates from known or novel sources must be shown to be safe—no presumption of safety.

• A precise product characterization is a key step in reaching compliance.

• Safety must be established and may be completed in parallel with claims studies.

• Claims must be based on the product or the clear identification of the component that substantiates a claim.

"Novel-Sourced Protein Ingredients: Critical Scientific Components for Regulatory Compliance," Ray Matulka, Ph.D., Director of Toxicology, Burdock Group Consultants

Inside Look at Developing Innovative Products

THE PRODUCT DEVELOPMENT PROCESS, plus challenges and solutions for four unique, novel protein products were outlined in "Case Studies: An Inside Look at Developing Innovative Products" by Jaime Reeves, Executive V.P., Product Development & Commercialization, Mattson. The presentation, given at the 2022 Protein Trends & Technologies Seminar, reviewed issues Mattson overcame as they worked to launch a ground beef alternative; a ready-to-drink (RTD) plant-based protein shake powder; a "sippable," high-protein bone broth concentrate; and a non-dairy soft serve.

In the first instance, J.B.S., a traditional meat company, sought to launch a line of plant-based meat alternatives, asking Reeves' team to develop them from concept to launch in six months. The challenge was that the prototypes were developed in Brazil and needed to be aligned with preferences in the U.S. market for characteristics such as size, shape, color and flavor. The Mattson team set aside these prototypes and started from scratch.

Fortunately, the parent company was plant-based protein "agnostic" (i.e., not preferential about the type of plant-based protein used), which allowed experimentation with different protein types and grind sizes that mimic the perfect burger.

Reeves noted that visually, the Impossible ™ burger "set a high bar for color change." Her team worked with dozens of ingredients, working out color issues with a blend of anthocyanins and red beet extract, finishing with a vegetable juice concentrate that would lend an acceptable brown hue to the finished, cooked product.

PHOTO CREDIT: KROSHKA_NASTYA/FREEPIK

Developing a non-dairy, plant-based soft serve required a formula that would run on two types of foodservice machines.

The fat content and type were critical contributors to sensory aspects, such as mouthfeel and texture, while impacting flavor release and color. The team turned to palm shortening to optimize flavor and the eating experience.

After solving development issues and conducting rapid-fire consumer testing, Reeves' team moved to scale up, where "nothing ever works the first time perfectly." At this stage, the team had to alter its methods "on the fly," changing the timing for TVP hydration and the order that ingredients were added to the formulation.

In the end, the team fulfilled its promise to complete its project within six months, enabling the launch of a new brand called "Ozo" in 2019. However, in October 2022, J.B.S. decided to discontinue its U.S. plant-based meat division, Planterra Foods, due to lackluster sales.

Powdered Drink Mix & Bone Broth

Next, Reeves outlined the development of a plant-based powdered beverage mix for the Pirq® company. Pirq makes RTD beverages and asked for a powdered version with great flavor, 20g of plant-based protein, no added sugar, no erythritol, the addition of probiotics that were not currently present in the RTD beverage, and 200mg curcumin and 500mg maca.

One challenge was determining the best plant-based protein for a powdered drink mix, considering behaviors such as foaming and flowability, among others, said Reeves. The team tested several gums to optimize viscosity, discarding xanthan gum and selecting guar. At least four rounds of product development were required to achieve flavor optimization and the correct sweetness profile. The project produced two Pirq Plant Protein Powdered drink mixes in Decadent Chocolate and Golden Vanilla, launched in 2022.

The third challenge was to create a great tasting, 95% organic concentrated, sippable bone broth with reduced sodium for Kitchen Accomplice that included at least 4g protein. "Making bone broth taste delicious is really difficult," said Reeves.

Her team screened several plant-based proteins to avoid foaming and achieve proper viscosity. Reducing sodium also posed a challenge, as salt reduces water activity (aw). The team needed to keep aw below .85. In the end, they created five SKUs, including a plant-based vegan bone broth.

Award-Winning Soft Serve

Finally, Reeves discussed the development of a new non-dairy, plant-based soft serve and custard frozen dessert for foodservice outlets for the Ripple® brand. The gold standard, in this instance, was the leading QSR soft serve.

The formula needed to be versatile and flowable to run on two types of foodservice machines. It had to be robust enough to withstand the freeze/thaw/heat holding requirements. And it had to be easy enough for the typical food service worker to use and pour into the food service equipment.

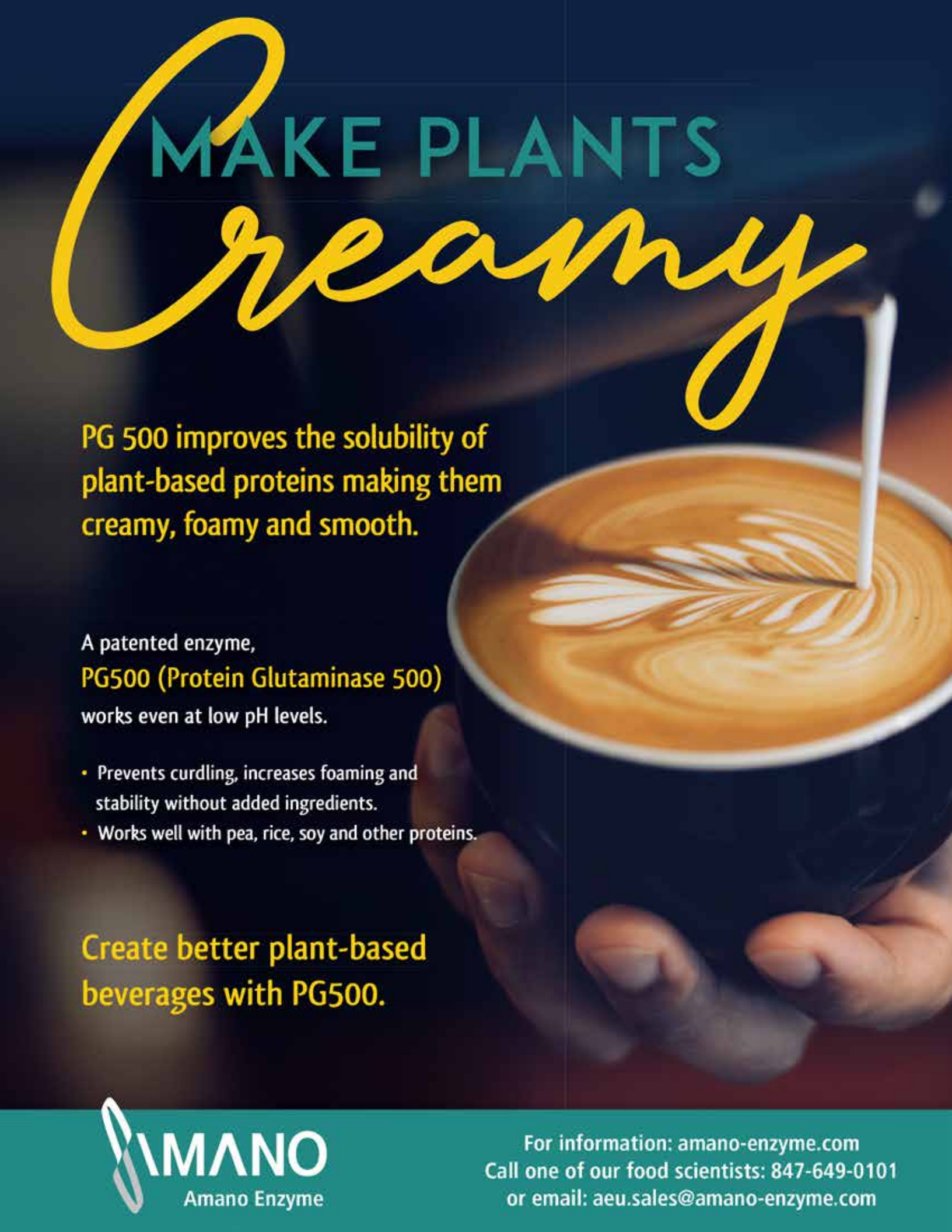
Formulation was one challenge, but it was also important to configure the programming or machine settings to work for a plant-based product, as opposed to running a dairy-based product through the machine. Another major challenge was the need for a foaming protein to provide overrun. Plant-based matrices make it difficult to incorporate enough air into the mixture to obtain the desired overrun. In this instance, the team selected a pea protein. It also needed a robust emulsifier with the food service machine setting allowing for greater leeway for the mono- and diglycerides.

The result was a rousing success, winning the FABI award at NRA for superior taste and its potential to revolutionize the food and beverage industry, said Reeves.

"Case Study Stories: An Inside Look at Developing Innovative Products," Jaime Reeves, Executive V.P., Product Development & Commercialization, Mattson [See the PowerPoint PDF at https://foodproteins.globalfoodforums.com/food-protein-rd-academy/four-case-studies-on-developing-protein-based-products-presentation/]

Protein Sources & Functionalities Impact Plant-Based Meats

PLANT-BASED MEATS AND MEAT ANALOGS form one of the fastest growing food industry segments, began Mian N. Riaz, Ph.D., Dept. of Food Science and Technology, Texas A&M University, in his presentation, "Raw Materials & Processes Shaping the Next Generation of Plant-Based Meat," at the 2022 Protein Trends & Technologies Seminar. Riaz detailed how protein sources and functionalities impact plant-based meats. He explained how a single parameter, such as a raw material's absorption, can influence dispersibility and texturization—ultimately influencing its performance during the extrusion process.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Soy protein, with its beneficial nutritional profile and excellent functional properties, is one of the most widely used plant proteins in plant-based meat formulations.

But what has been driving the plant-based meat segment growth? In part—plant-based diets are becoming more mainstream, and consumer demand that plant-based meats resemble traditional meat products and are available in a broad spectrum of categories.

These changes are being driven in large part by Gen Z. Other factors driving the consumption of these products include healthfulness and health claims; the use of high-quality proteins as a base; environmental concerns; and, most importantly, overall taste. The bottom line is that these products "must meet consumer expectations for taste, texture and juiciness," emphasized Riaz.

Sources of Plant-Based Protein

Today's ever-expanding stable of plant-based meats is manufactured from a wide range of plant sources, including (but not limited to) soy, wheat, peas and beans, algae, potato and mushrooms. Each protein source has different characteristics and functional properties that must be addressed during product development. Among the functionalities that affect the overall sensory properties of plant-based meat products are water-holding capacity, emulsification properties, gelation and fat absorption. These functionalities affect finished products' appearance, aroma, color and mouthfeel.

Each protein source has distinct advantages and disadvantages that influence its selection. For example, pulses (peas and beans) may be used if a processor wants to eliminate allergen issues inherent with soy and wheat, noted Riaz.

Unique differences exist between meat proteins and those derived from plants. Meat proteins are fibrous, whereas plant proteins are globular. "These structural differences impact formulation and affect the finished product's taste, texture and juiciness," said Riaz. To address this issue, which is essential for duplicating the flavor, texture and appearance of meat products, developers must understand the raw material in its various forms; how different additives affect the protein matrix; and how the extrusion process affects overall formulation.

The protein source and its final concentration in formulation affect product characteristics such as texture and color. Higher protein levels yield tougher textures in finished products, whereas lower levels yield softer products.

It is not just the protein type or concentration that affects end-product performance but also the particle size of the protein. A coarse protein will hydrate more slowly and may adversely affect how the product grinds. A protein that is too fine may ball up and not redisperse.

Developer Considerations

"The developer should not simply select soy protein but must consider other options, such as soy flour and soy protein concentrate—each of which has different characteristics that impact texture and water absorption," explained Riaz. "Similar decisions must be made when utilizing other proteins, such as peas, chickpeas, lentils, fava beans and navy beans, among others. For instance, pea protein concentrate has 46% protein, whereas pea isolate has 85% protein. Each protein source also varies in fiber, oil, sugars and starch levels. Protein sources and protein quality influence product characteristics, resulting in different colors, flavors and nutritional profiles and the ability to form fibers," he added.

Proteins and how they perform are the centerpiece of the development process. Other ingredients, such as carbohydrates and edible oils, as well as surfactants like lecithin, natural/artificial colors—and flavors, including salt—plus the use of acids or bases all play a role in the final product formulation and its overall performance, noted Riaz.

Carbohydrates or starches may enhance surface appearance by smoothing and rounding it. Finished product pH values can be adjusted with bases, such as calcium or sodium hydroxide, that optimize overall texture. A pH over 8.0 results in poor textural integrity, whereas a pH under 5.0 forms significant sour flavors.

The final step in the process is the creation of High Moisture Meat Analogs (HMMA) through the extrusion process. This texturizes the proteins and creates the overall appearance and flavor profile that the public demands from plant-based meat analogs.

"Raw Materials & Processes Shaping the Next Generation of Plant-Based Meat," Mian N. Riaz, Ph.D., Associate Dept. Head and Holder of the Professorship in Food Diversity, Dept. of Food Science and Technology, Texas A&M University

Formulating Nutritionally Equivalent Non-Dairy Cheese Analogs

COWS CAN TURN FOOD WASTE into the highest quality protein available on the planet, but global food conglomerates struggle to produce non-dairy cheese analogs with the nutrition, taste and texture of dairy cheese. So began Jonathan Gordon, Ph.D., President, Glasgow Growth Partners. His presentation titled "Where's the

Protein? The Challenges of Formulating Non-Dairy Cheese Analogs with Similar Nutrition to Their Dairy Equivalents" was given at the 2022 Protein Trends & Technologies Seminar. He went on to compare dairy- vs. plant-based "cheeses."

For example, dairy mozzarella is a protein matrix with about 5.7g of protein per ounce, while a typical non-dairy mozzarella is a starch matrix with little to no protein. "Casein is a complex protein molecule and, after decades of research, we still don't completely understand it," said Gordon. In contrast, we understand the structure of soy and plant proteins quite well.

Milk protein is some 80% casein and 20% whey protein. Many plant starches are 80% amylopectin and 20% amylose. Amylose is a wonderfully ordered molecule composed of single glucose units that sterically orients into a spiral that can stack easily. A single fatty acid can be bound to the starch molecule by fitting into the center of the spiral. When non-dairy cheese is made predominantly with starch, for the first four to six days it is "mush." However, if coconut fat is used, it will somewhat resemble dairy cheese texture over time, said Gordon.

In dairy mozzarella, casein strands are bound and cross-linked by calcium phosphate with interstices of fat and serum, which creates the cheese structure. The analogs will melt into sauce in starch-based cheese, but they don't have good stretching properties—the amylopectin molecule tangles, which prevents stretch. The challenge is to prevent tangling and end up with a relatively ordered structure.

Adding protein to the starch matrix of typical non-dairy, "hard" cheese typically results in soft end-products, admirably marketed as pub cheese or queso. Non-dairy cheeses with a small amount of added protein have proven suitable for soft cheeses and spreads, said Jonathan Gordon, Glasgow Growth Partners.

Hard dairy cheese generally contains 35 to 45% fat, with dairy protein functioning as a good emulsifier. The structure of dairy cheese is proteinaceous, but there is no such structure in non-dairy cheese.

Challenges in Adding Protein

One challenge of adding protein to the starch matrix is the difference in size between large soy protein and smaller starch molecules. Protein molecules won't fit in the starch structure without causing considerable disruption to its continuity, resulting in a soft, mushy product. It is possible to formulate "hard" cheeses with up to 4g of protein per serving in a traditional starch matrix, using discrete bacterial proteins (high-protein bacterial cells), advised Gordon.

A vegan cheese sandwich is basically a meal of carbohydrates without any protein. Newer analog products that rely on adaptations of artisanal, traditional cheese processing use plant-based milk, such as cashew milk, as the starting material. Even though cashews start with 18% protein, the finished non-dairy cheese ends up with only 4g per ounce. When one tries to make cheese in the traditional way from non-milk protein, the result is a less satisfactory level of protein, flavor and texture. And, when vegetable proteins are fermented, they tend to turn brown rather than white.

The "zipper theory" of casein stretch is that casein has an incredible ability to form temporary attachments—like a zipper. This is an inherent quality of casein which does not occur in vegetable protein.

Cheese analog manufacturers now use varying combinations of hydroxy-propylated potato starch and native starch to approximate the melt and stretch of cheese. Gordon noted that the fat level, moisture level and pH determine the melt properties of dairy cheese. In plant-based cheese, combining modified starches and coconut oil produces a waxy mouthfeel and stretch. One can work with various ratios of starches to approach cheese texture. However, vegetable protein can't form intermittent sliding attachments. In the case of tofu manufacturing, you can create a beautiful protein structure. However, tofu does not melt at all, he added.

Milk Matters

It is difficult to reproduce the flavor components of milk as well. Cows' milk contains at least 25 proteins and 400 discrete fatty acids. Adding some citric acid makes it possible to stimulate the diacetyl pathway and obtain some buttery flavor notes. Flavors that resemble blue or Camembert cheese are produced if one adds a mold.

To create desirable flavor in analog cheese, you must add vegan flavors from flavor houses. By culturing non-dairy milk, you can get certain cheese flavors, such as Cheddar notes. However, you can't replicate the immense complexity of real cheese. The flavors you get when you culture vegetable proteins tend toward brown flavors, like umami and miso.

Nutritionally, we can use soy protein or blend pea and other proteins to achieve a good PDCAAS. Minerals also play an essential part in cheese flavor. Adding phosphates and potassium can improve flavor.

"Rather than trying to emulate dairy cheese, is it better to create something entirely new?" Gordon rhetorically asked the audience. If we use our intuition; combine the right amount of starch, protein, minerals and fat; and achieve flavor through artisanal fermentation, we can produce something that flexitarians will eat.

"Where's the Protein? The Challenges of Formulating Non-Dairy Cheese Analogs with Similar Nutrition to Their Dairy Equivalents," Jonathan Gordon, Ph.D., President, Glasgow Growth Partners

Science of Protein Metabolism Informs Product Developers

BOB MURRAY, PH.D., FACSM, Managing Principal, Sports Science Insights, LLC and Co-founder and former Director, Gatorade Sports Science Institute, provided an insightful presentation titled "The Science of Muscle Protein Synthesis: Practical Takeaways for Product Developers" at Global Food Forums' 2022 Protein Trends & Technologies Seminar. During his presentation, Murray described how dietary protein stimulates muscle protein synthesis (MPS) and how the science of protein metabolism can inform product developers.

Murray's presentation described key practical findings related to the role of protein in muscle protein synthesis (MPS). Examples of 13 product benefit claims ranged from "supports workout recovery" to "repair-, rebuild- and/or maintain lean muscle and body tissue."

"There is robust evidence that protein intake with training enhances MPS, lean body mass (LBM), strength and performance," he noted, "with the one exception being 'energizing protein to fuel your day.'" Protein is not a nutrient that our cells preferentially use for energy. Instead, carbohydrates and fats are used.

Results from 49 studies with 1,863 participants showed that dietary protein supplementation increased prolonged resistance exercise

Plant and animal proteins, protein blends, protein hydrolysates and amino-acid mixtures in solid or liquid form are effective in increasing MPS, provided there is enough rapidly digested/absorbed, high-quality protein rich in leucine and other essential amino acids.

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training (RET)-induced gains in muscle mass and strength. Gains in LBM were reported to be more effective in resistance-trained individuals. Protein supplementation beyond the total intake of 1.6g/kg/day resulted in no further RET-induced gains (Morton, RW, et al. Brit J Sports Med. 2018/https://bit.ly/3Dz933U).

Strength training and eating a meal rich in essential amino acids (EAA) increase protein synthesis. This cellular mechanism is dependent on a cascade of protein kinases, along with the activation of the mammalian target of rapamycin (mTOR). When training and protein intake are combined, the effects add up and result in a more significant impact on MPS than either strength training or eating alone. Proteins that result in a rapid and prolonged (~1 hour) increase in the EAA leucine in the blood maximize the activation of mTOR and the increase in MPS and strength (Baar K., *Sports Sci Exchange*. 2014/ https://bit.ly/3fyNnN6).

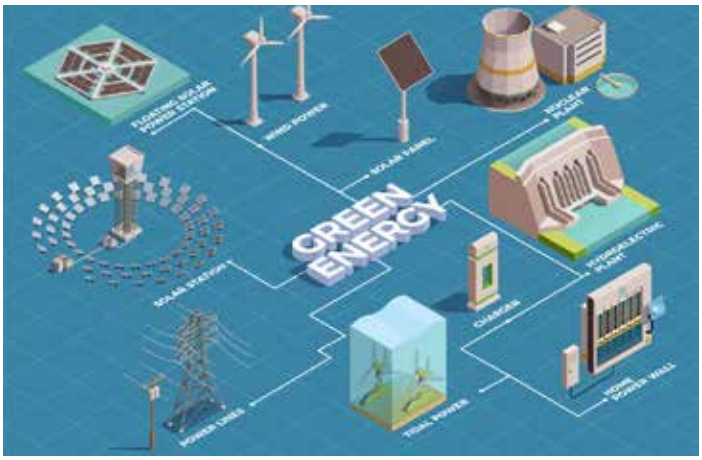
"It seems intuitively reasonable that increasing strength will increase performance. This relationship isn't clear-cut, as it is difficult to study and depends on the performance metric being measured. However, this benefit claim is unlikely to be challenged," explained Murray.

Protein Metabolism Science Guides Product Development

The science of protein metabolism can inform product development. Muscle protein basics tell us that, for a 70kg body weight, there is about 12kg of total body protein with 250g total free AA and 120g AA pool within muscles. But muscle is only ~30% of whole-body protein synthesis—a relatively small amount recognizing that muscle represents only 20% of resting metabolic rate.

"Muscle contractile proteins turn over slowly at ~1g/kg/d," revealed Murray, "and only about 10% of ingested AA are used by muscle." The elderly may require more than 20-25g of protein in a single serving to optimize MPS because of resistance to the anabolic effects of AAs that occurs with age. Large athletes may need more as well.

The type of protein affects MPS, with research showing EAA in plasma are highest and appear most rapidly with supplementation of whey hydrolysate, followed by soy protein isolate and then casein.



Similar results were noted for the appearance of leucine (Tang, JE, et al. *J App Physiol*. 2009/ https://bit.ly/3T7e1ue).

Murray also provided information on animal vs. plant proteins. Plant proteins typically have a limiting EAA profile, which can be overcome by combining plant sources. Both plant and animal sources contain leucine and other branched-chain amino acids (BCAAs), and their contents can be increased using concentrates and isolates. There are a variety of plant and animal foods and ingredients that contain similar amounts of BCAAs.

Males and females appear to respond similarly to dietary proteins. Plant and animal proteins, protein blends and hydrolysates, and AA mixtures (e.g., EAAs, BCAAs) can effectively increase MPS. There is more rapid absorption with liquid vs. solid protein supplementation.

"MPS will be enhanced with the presence of all EAA, as well leucine (2-4g/serving appears optimal), but any leucine is better than none. Suppose a product has a sub-optimal amount and/or type of protein. In that case, MPS can be improved by including carbohydrates, beta-alanine, vitamin C, creatine, collagen, carnitine and omega-3 fats," explained Murray.

Murray summarized his talk with the following takeaways:

1. Most current structure-function claims for protein foods formulated for athletes and active consumers are well-supported by competent science.

2. Plant and animal proteins, protein blends, protein hydrolysates and amino-acid mixtures in solid or liquid form are effective in increasing MPS, provided there is a sufficient quantity of rapidly digested/absorbed, high-quality protein rich in leucine and other essential amino acids.

3. The scientific link between increased dietary protein content and improved sports performance (via increased muscle mass and strength) isn't well established and remains to be consistently verified by research.

"The Science of Muscle Protein Synthesis: Practical Takeaways for Product Developers," Bob Murray, Ph.D., FACSM, Managing Principal, Sports Science Insights, LLC and Co-founder and former Director, Gatorade Sports Science Institute [See the PowerPoint PDF at https://foodproteins.globalfoodforums.com/food-protein-rd-academy/formulating-products-with-muscle-protein-synthesis-in-mind-presentation/]

Sustainability Considerations Dairy vs. Plant-Derived Protein

MANY FOOD PROCESSES CAN BE MADE more sustainable in today's global push for greater environmental responsibility, noted Jacob Smith, Ph.D., Innovation Analyst, RTI Innovation Advisors.

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EverPro's Functional Benefits

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- No gelling or water holding capacity.
- Minimum flavor impact.

Potential Environmental Sustainability Goals

DAIRY Inputs	Outputs or Secondary	PLANT-DERIVED Inputs	Outputs or Secondary
New pasteurization tech	Upcycle waste streams	New crop varieties	Upcycle waste streams
New refrigeration tech	Reclaim evaporated water	New fractionation tech	Reclaim evaporated water
New membrane tech	Reclaim waste heat	Novel processing aids	Reclaim waste heat
Improved drying tech		Improved drying tech	New ANF & off-flavor removal methods

SOURCE: RTI INNOVATION ADVISORS/2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

Whether dairy- or plant-based, opportunities exist when looking for more sustainable processes.

However, he specifically focused on sustainable opportunities of dairy vs. plant-derived protein ingredient processes in his presentation titled "Sustainability Considerations of Dairy vs. Plant-Derived Protein Ingredient Processing," given at the 2022 Protein Trends & Technologies Seminar. Whether considering dairy- or plant-based ingredient processing, each process has inputs, secondary inputs (i.e., outputs from the previous step), process steps and outputs.

Many protein-based ingredients are produced from milk or whey (a by-product of cheese-making) with various protein content percentages. These ingredients include milk protein concentrate, milk protein isolate, micellar casein concentrate, sweet whey powder, demineralized whey, reduced lactose whey, whey protein concentrate and isolate, lactoferrin and α-lactalbumin.

Processing Dairy or Plant Proteins

Much of what occurs during processing is a physical separation through membranes, noted Smith. Every time something passes through a membrane, a retentate and permeate result. The retentate moves to the next step, while the permeate is considered a waste stream; in the dairy industry, "a lot of the permeates are recycled as part of the process," Smith said.

In plant-based protein ingredient processing, many botanical sources are used to produce protein concentrates, isolates or other formats with different functionalities using wet or dry fractionation. If you have an oilseed, you'll need to undergo an oil separation before fractionation.

Smith said that dairy- and plant-based protein ingredient processing relies on inputs like raw material, energy, water, chemicals and enzymes to produce outputs—including protein ingredients, co-product side streams, wastewater and waste energy. Separation, evaporation and drying are common across both sides, which "may present opportunities to innovate and enhance the sustainability of the processes," he emphasized.

Water usage is highly dependent on the process. With milk consisting mainly of water, dairy brings much of its water to processing. Also, the permeate can be reclaimed and reused in dairy processing, and casein wash can be processed as whey. On the other hand, significant quantities of added water are often required for plant-derived ingredient processing. Water produced during plant-derived manufacturing is typically not currently reclaimed.

Regarding processing aids, dairy processing typically uses only enzymes or acids and bases across production processes. For plant-derived ingredients, wet fractionation requires the use of significant quantities of acids and bases for isoelectric precipitation.

Typically, a base is added to increase the pH and aid protein dissolution, while facilitating the removal of insoluble impurities through filtration. Next, acid is added to precipitate the purified protein out of the solution. Enzymes may be leveraged to aid in the dissolution of the raw material slurry or in breaking down molecules known to impart off-flavors to end-products. Organic solvents, such as hexane and ethanol, are used for oil extraction and occasionally for off-flavor or anti-nutritional factor removal.

"One of the most important things to the industry is off-flavor removal," Smith said. "Even pulses and raw materials that have relatively low fat content may need to be washed with an organic solvent to remove some of those off-flavor molecules that have an extremely low sensory threshold," he added. Whether these processing aids end up in the waste stream can factor into the reusability of that stream.

Recycling & Upcycling Protein By-products

Smith noted that dairy co-product streams currently tend to find more value-added uses in food applications than plant-derived proteins, because the industry has put much research into upcycling by-products from processing.

Plant-derived ingredient processing recycles some of its co-product streams. For example, the soluble fiber portion of oat bran (i.e., beta-glucans) provides an excellent source of dietary fiber. Starches and flour by-products can be further modified for specific functionality in applications. In another example, aquafaba, the liquid stream produced during chickpea processing, has excellent functional properties. However, unlike milk permeates, solubles from plant-derived manufacturing may not be suitable for secondary use without further processing, as they contain off-flavor producing molecules as well as anti-nutritional factors, Smith noted.

Thermal processes such as drying present an opportunity to improve energy efficiency across dairy and plant ingredient processing. Smith suggested that if you're looking at water reclamation, there's quite a bit of opportunity to recollect evaporation and reuse it in some form.

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While consumers may perceive plant-derived ingredient processing as more sustainable, the mature dairy industry has had far more time to work with its by-product and waste streams. (See the chart titled "Potential Environmental Sustainability Goals," which demonstrates opportunities for sustainability improvements on both sides.)

Perhaps the energy used during thermal steps can be reduced; membrane technologies made more efficient; or heat generated through refrigeration reclaimed on the dairy side. On the plant-based side, research is being done on electrostatic-based fractionation to improve ingredient concentration, noted Smith. And there's much room for growth in upcycling waste streams and water reclamation.

Whether dairy- or plant-derived process is more sustainable depends on the intricacies of the process. "Hopefully, both sides of the table can learn something from each other in ingredient processing sustainability," Smith concluded.

"Sustainability Considerations of Dairy vs. Plant-Derived Protein Ingredient Processing," Jacob Smith, Ph.D., Innovation Analyst, RTI Innovation Advisors [See the presentation PowerPoint at https://foodproteins.globalfoodforums.com/food-protein-rd-academy/dairy-vs-plant-based-protein-sustainabililty-potential-presentation/]

Keto: The Future of Baking

LIN CARSON, PH.D., FOUNDER & CEO, BAKERpedia, described how keto baking targets the unique properties of wheat protein and sugar in her presentation titled "Future of Baking: High, Protein, Low Net Carbs & Keto Baking Hacks," given at the 2022 Protein Trends & Technologies Seminar by Global Food Forums.

In the standard bread-baking process, wheat flour supplies the protein component and colorization through Maillard browning. In wheat flour, gluten and starch form a gel structure upon heating. Damaged starch and flour provide food for yeast, producing gas trapped within the network structure, thereby improving volume. Sugar functions as food for yeast; a humectant; bulking agent; improves color and flavor; and reduces water activity (aw). Minor ingredients comprise <2% of the formulation. Fat improves mouthfeel and sliceability, and preservatives prolong shelflife.

In keto bread processing, WPI can be tailored to a specific protein quality and quantity.

What Are Net Carbs?

Total Carbs – Fiber – Sugar Alcohols = Net Carbs

When targeting zero net carbs for bakery goods, the key is to increase the fiber content or replace the carbohydrate component with resistant starch to bring the above equation to zero net carbs.

The keto diet = 70% fat, 20% protein and 5% carbs. Suggested Daily Intake of Net Carbs is < 30g.

—Lin Carson, Ph.D., BAKERpedia

Designing Ingredient Systems

"The secret to the success of producing keto bread is by designing ingredient systems or matrices, rather than using one ingredient replacement," emphasized Carson. In keto breads, modified wheat starch (MWS) or resistant starch (RS) provides the bulk of the formula. RS does very little rheologically; therefore, there's a minimal reaction between starch and water and starch and yeast. When used in combination with wheat protein isolate (WPI), which is the protein source in the formulation, viscoelastic properties are impacted—like those of wheat flours in bread, as well as yeast and chemically leavened baked foods, Carson noted.

"In the white bread baking industry, few keep an eye on protein quality and how it disrupts production processes," alleged Carson. "Specifically with keto baking, you can specify the WPI to its proper protein quality and quantity. With this comes less dependence on dough conditioners, elimination of vital wheat gluten and consistent water absorption; therefore, [there is] less variability in output rates and a reduction in waste levels," she added.

In keto breads, fat can be used up to 8%. Carson cautions against using a higher level; otherwise, the fat will break down the gluten matrix, making the bread more friable. Inulin is typically used at 2-5% in a bread formula. Oat bran's nutritional profile makes it a value-added ingredient with wide versatility, including moisture regulation, texture addition and shelflife extension.

If sugar is missing, yeast will use various mono- and diglycerides, but these aren't prevalent in keto formulas. And MWS doesn't contain very much damaged starch; however, inulin provides residual starch for yeast. Yeast levels can also be increased, and a different source of CO2 (i.e., baking soda, baking powder) can also aid in leavening.

Alternative sweeteners, such as stevia, monk fruit, erythritol and allulose, can be used. A 1:1 replacement of sugar with allulose may be preferred, because it provides bulking and browning like sugar. Chia fiber or other fibers impart bulking, as well. Preservatives, such as calcium propionate, encapsulated sorbic acid and cultured wheat, are important; this is because the absence of sugar increases aw, thus their susceptibility to mold.

In keto cakes, an alternative sweetener such as allulose adds bulk and color to the cake; fat adds tenderization; gums and emulsifiers add stability; resistant starch (fiber) acts as the filler/bulking agent; chia flour can improve the viscosity of the batter; and encapsulated sorbic acid or potassium sorbate help extends shelflife.

Protein Quality & Color Improvement

WPI, whey or eggs add protein, though the protein quality is less important in keto breads, noted Carson. "A good long bake at a lower temperature will allow for a better release of water to lower the aw," she explained. Leavening agents typically need to be higher than in standard cakes for a fluffier texture, because fat, gums, chia flour and fiber make for a denser cake.

The golden-brown color of keto cookies can be improved by introducing more protein and reducing sugars (i.e., allulose) or by increasing the pH via baking soda. Chemical leavening incorporates more air into the batter, softening the finished product. A crisper cookie can be made by increasing ingredients that have a higher glass-transition temperature. Chemical leavening is variable and dependent on the formulation (i.e., high protein vs. frozen). And, to control mold, keep liquids below 10%.

While creating high-quality, keto-baked products without the unique properties associated with wheat protein and sugar has its challenges, the keto-baking industry has seemingly risen to the task.

"Future of Baking: High, Protein, Low Net Carbs & Keto Baking Hacks," Lin Carson, Ph.D., Founder & CEO, BAKERpedia [Access the PowerPoint presentation at https://foodproteins.globalfoodforums.com/food-protein-rd-academy/keto-baking-for-bread-cake-and-cookies-presentation/]

Specialty Protein Testing in Product Development

THERE IS A GLOBAL NEED for high-protein foods. Hence, the need exists for protein-rich ingredients to develop and bring these end-products to market, said Cosmin Beliciu, Ph.D., Project Leader, Product and Process Development, The National Food Lab, Inc. In his presentation, "Streamlining Product Development Using Specialty Protein Testing," given at Global Food Forums' 2022 Protein Trends & Technologies Seminar, he noted that the demand varies. It includes traditional proteins (dairy, egg, meat and fish) and the ever-expanding field of plant-based proteins from various sources.

Designer proteins produced via fermentation or culturing are also increasing their presence on the market. In developing protein ingredients, close attention is paid to their functionality as related to their targeted use in a wide range of products and formulations.

Plant Protein Boom

The market for food protein ingredients was valued at more than $52 billion in 2021 and is expected to nearly double to $103 billion by 2030, according to an August 2022 report by Acumen Research. Plant-based proteins have led this charge, and plant-based products have seen hundreds of new product releases and significant increases in shelf space in retail markets.

Innovation in raw material development and sourcing, plus a concerted effort by suppliers to optimize ingredients and enhance overall functionality, has helped fuel this demand, noted Beliciu. This has been brought about by developing equipment and technologies that allow the industry to meet these goals. Desirable functional properties include gelation; solubility over a wide range of pH values; as well as flavor, foaming, heat stability and viscosity.

Assessing Protein Potential

To quickly evaluate the performance potential of any protein, specialty protein testing has evolved as a vital part of the manufacturer's and product developer's toolbox. These tests can establish the functionality fingerprint of a protein ingredient; characterize its performance in different applications; run comparative stability checks for process development; and conduct technical viability checks. This toolkit can include tests for solubility, pH and heat stability, water-holding capacity, emulsion capacity and stability, foaming capacity and stability, SDS-Page, Zeta potential and viscosity, yield stress and flow index.

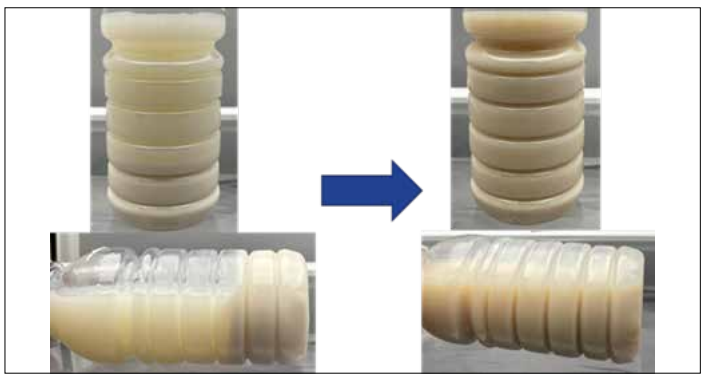

PHOTO CREDIT: C.BELICIU, THE NATIONAL FOOD LAB (NFL) / 2022 PROTEIN TRENDS & TECHNOLOGIES SEMINAR

Specialty protein tests can speed the development of applications such as drinks based on blends of various proteins. In the picture above, a synergistic blend of proteins was used to prevent sedimentation with no added stabilizers.

The objective is to establish an ingredient's potential in various applications and focus product development on the best performing protein ingredients. Traditional product development resembles a "hunt and peck" approach, with lots of trial and error and a lower efficiency, with stepwise progress toward the final product. In contrast, the attribute performance approach builds on screening a larger number of ingredients to establish their functionality fingerprint, then using application-specific filters to identify high-potential ingredient options to use in development. The latter approach is science-based, more efficient, reduces the time it takes to bring the product to market and reduces costs, advised Beliciu.

Beliciu went on to look at how the specialty approach is applied to some of the testing methods. For example, to evaluate emulsifying properties, a few different methods can be used: emulsifying capacity can identify the maximum amount of oil that a unit of protein can stabilize before the emulsion would invert from oil-in-water to water-in-oil. Emulsion stability can also be measured by preparing dilute emulsions that can be characterized using spectrophotometry.

In another example, SDS-PAGE was used to establish qualitative protein composition and molecular weight characterization. This enabled process impact assessments (for example, in heat treatments that would lead to protein denaturation); ingredient characterization (if enzymatic methods are used); stability evaluations; or troubleshooting. These two tests and others can help product developers get from concept to final product more quickly, efficiently and at a lower cost.

Beliciu offered a test case. The National Food Lab product developers used the following tests for a high-protein beverage formulated with a protein blend. Heat stability, viscosity and flow index measurements were used to select the best-performing proteins. Zeta potential and particle size distribution analysis were used to determine the protein-driven process and storage stability. And a centrifugal dispersion analysis assessed the potential for sedimentation. This testing regimen allowed the researchers to overcome the existing challenges and produce a product with good viscosity and flow characteristics, minimal stabilizers, good storage stability and a neutral flavor profile that could be used for consumer-driven flavor development.

The specialty testing tool kit may be used by ingredient suppliers and consumer packaged goods companies (CPGs) to develop and quickly evaluate new ingredients or products. Ingredient suppliers can use it as a guide in their iterative ingredient development process. CPGs can use it to create alternative plant-based products that perform similarly to traditional products, to branch out into new markets, for supply chain management, cost improvement projects or for process troubleshooting.

"Streamlining Product Development Using Specialty Protein Testing," Cosmin Beliciu, Ph.D., Project Leader, Product and Process Development, The National Food Lab, Inc. (The NFL)

The Growing Regenerative Agricultural Opportunity

KERRY HUGHES, MSc, began her presentation, "Regenerative Agriculture: What's Behind the Fast-Growing Animal & Plant Protein Market Opportunity," given at the 2022 Protein Trends & Technologies Seminar, by discussing how the global conversation has changed from "sustainability" to "regeneration."

What we have now in agricultural lands and many wild areas cannot be sustained—we need regeneration. "Many scientists are today warning us that we stand at the brink of the 6th Mass Extinction," and are confronting the statistic that 75% of the earth's land areas have been degraded (according to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services report [https://ipbes.net/]).

Hughes framed the statistic that regenerative agriculture is projected to grow at a CAGR of 14.4% through 2030, and made comparisons with the growth of organics over the past decades. For example, she stated that many large companies have already announced commitments towards regenerative production, as consumers intuitively like and are receptive to regenerative agriculture. She pointed out the commitments:

- In 2020, Whole Foods Market announced regenerative agriculture would be the "No.1 Food Trend."
- Nestle is investing $1.24 billion into "regen ag" across its supply chain.
- PepsiCo wants to spread its regenerative agricultural practices across 7 million acres.
- General Mills reports 115,000 acres enrolled in the regenerative program with a target of 1 million acres by 2030.
- Walmart committed to advancing regenerative agriculture on 50 million acres.

The above commitments totaled over 58 million acres. Hughes compared this to the fact that, after decades of organic farming,

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With much of agricultural land no longer "sustainable," the global conversation has moved to work toward regenerative agriculture.

there are only 5 million acres under organic production in the U.S. Although there is no agreed-upon definition, according to Hughes, one retailer says they are "hanging their hats on five key soil health principles when talking about regenerative agriculture: minimize soil disturbance, living roots, keep the soil covered, animal integration, and diversity and biodiversity."

Without a central definition, third-party product verification is essential to ensure against greenwashing. Hughes overviewed the three most prominent third-party seals.

- Land to Market (EOV) is a verification that uses ecological indicators to measure regeneration through an outcome-based approach. Peers conduct audits in this system. Verified operators are supported through a Land to Market Regenerative Supply Roster.
- Regenerative Organic Certification (ROC) is a true certification that requires organic certification before the regenerative certification can be applied. It offers standards on soil health and land management, animal welfare, and farmer and worker fairness. ROC also offers equivalencies with other standards for select pillars (such as Biodynamic and Animal Welfare Approved by AGW).
- Most recently to market, Certified Regenerative by AGW (CR by AGW) is another true certification. It does not require organic certification for farms. CR by AGW audits against a detailed regenerative farm plan as a basis for certification and requires they meet standards on soil, water, air, livestock, land use and cropping, biodiversity (including wild harvest), buildings, social responsibility and financial sustainability.

Regenerative Agriculture

Soil health is at the root of regenerative agriculture, not just a focus on organic matter. It is crucial to manage soils for soil health and as living systems to benefit from the ecosystem services soils provide. Hughes pointed to a growing movement to include biodiversity as an indicator for environmental regeneration. "We know now that when several species are growing together, they have a wider set of mechanisms that they can use to gain resources needed for life," she added.

Hughes gave further details on the CR by AGW standard and gave this definition: "A set of planned agricultural practices that ensure the holding is not depleted by agriculture practices, and over time the soil, water, air and biodiversity are improved or maintained to the greatest extent possible."

She also elaborated that it is not only outcome-based but a technological tool for the farmers to assess if their regenerative practices are working. Additionally, CR by AGW does something important: generate data. Every farm holding must annually track indicators of biodiversity and two indicators of soil health.

Hughes closed by explaining how every CR by AGW regenerative plan is crafted by a qualified expert, an experienced regenerative farmer, and/or a traditional expert and/or a keeper of traditional ecological knowledge.

She gave a case study of the first CR by AGW holding, Challacombe Farm, a 185-hectare Duchy of Cornwall farm on Dartmoor in southwest England. The holding had significant challenges in the form of extensive archeology stretching back 3,500 years. Also, most of its land area is designated as a Site of Special Scientific Interest (SSSI) or County Wildlife Site for wildlife. For this reason, CR by AGW and regenerative techniques were beneficial when applied to their holding. The land stewards found that the external, independent assessment helped them think about and define their plans to farm in harmony with nature and properly measure and monitor their goals over time.

"Regenerative Agriculture: What's Behind the Fast-Growing Animal & Plant Protein Market Opportunity," Kerry Hughes, MSc, President of Ethnopharm LLC, Advisor for A Greener World [To access an updated and expanded presentation PDF, see https://foodproteins.globalfoodforums.com/food-protein-rd-academy/segueing-from-sustainable-to-regenerative-agriculture-presentation/]

We at Global Food Forums would like to thank the attendees, speakers, sponsors and exhibitors at the 2022 Protein Trends & Technologies Seminar for their support. As these diverse groups gather to share information, network and enjoy each other's company, a more valuable and enjoyable event has resulted.

VITALUS

MILK PROTEIN

Concentrate (MPC) and Isolate (MPI)

Application ideas

- RTD
- YOGURT
- SNACK
- BAKERY
- CONFEC-TIONARY
- CHEESE
- SOUP
- ICE CREAM

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2022 Protein Trends & Technologies Magazine Advertiser Profiles

Ingredients that inspire innovation. For over 20 years, **Applied Food Sciences (AFS)** has inspired and innovated functional ingredients for the natural products industry. Quality is transparent through organic farming, responsible sourcing and sustainability. AFS cares about every stakeholder, from rural farmers to the largest companies in the world. We are featuring PurHP-75™ organic hemp seed protein–75% protein complete with all nine essential amino acids and a neutral flavor profile. https://appliedfoods.com/ingredients/purhp-75/

Founded in 1938, **Agropur** is a top-20 global dairy producer. With sales of $7.3 billion CAD in 2021, it processes more than 14 billion pounds of milk annually at its 31 plants across North America. The organization, which operates as a cooperative in Canada and a private company in the United States, is a source of pride for its 2,974 members and 7,700 global employees who work together in pursuit of a shared vision: "Better Dairy. Better World." https://www.agropur.com/us/

AIDP, Inc. is an industry leader in developing and sourcing innovative ingredients for the health, functional food and beverage industries. AIDP provides advanced plant proteins with a special focus on pea proteins. We also provide complimentary ingredients for clean texture and lift, including RisaBran and sustainably sourced Alginates plus a new line of reduced sweeteners and functional mushrooms. AIDP's portfolio features clinically supported ingredients for cognition, digestive health, Immune support, sports nutrition and much more. https://aidp.com/

Founded in 1899, **Amano Enzyme** is a worldwide enzyme manufacturer with subsidiaries in the USA, Europe and Asia. Amano Enzyme USA manufactures microbial source, non-GMO enzymes that enhance a number of aspects of plant-based foods and beverages from flavor and texture—to anti-curdling, foaming and frothing properties. Our enzymes also improve the solubility and physical properties of proteins; enhance dairy flavors; and aid in the production of whey/casein hydrolysates. https://www.amano-enzyme.com/

Apparo's mission is to improve the food system's sustainability by upcycling nutritional ingredients from plant-based byproduct streams. Using Total Crop Utilization™, our development program, we extract two sunflower protein isolates (Solistein™ 001 and 002) from sunflower seed meal. Each has over 90% protein, unique functionalities and superior flavor to other high-protein ingredients. Based in Eden Prairie, MN, we are excited to be working to bring these highly sustainable, non-GMO and gluten-free protein ingredients to the food and nutrition development community. https://www.apparo.us/

Benson Hill moves food forward with the CropOS® platform, a cutting-edge food innovation engine that combines data science and machine learning with biology and genetics. Benson Hill empowers innovators to unlock nature's genetic diversity from plant to plate, with the purpose of creating nutritious, great-tasting food and ingredient options that are both widely accessible and sustainable. More information can be found on Twitter at @bensonhillinc or at: https://bensonhill.com/

Cosun Protein is committed to enabling the creation of a new generation of plant-based proteins. A generation with great taste, which is produced locally and sustainably. Cosun Protein creates neutral tasting, highly soluble plant proteins ideally suited to a broad range of food and beverage applications. Our high-quality Fava Protein Isolate, which is neutral in taste, is a game-changing ingredient that is a result of our proprietary extraction technology and unique process. www.cosunprotein.com

®CP Kelco is a nature-based ingredient solutions company with state-of-the-art innovation centers, manufacturing facilities and technical experts around the globe to empower your product development. Our multifunctional portfolio can address protein stabilization, suspension, texture and mouthfeel to support your formulation challenges and clean label goals. We leverage our regional insights, ingredient innovation and problem solving to help you create the next generation of protein products. https://www.cpkelco.com/

Introduced in 2021, **EverGrain®** is a sustainable ingredient company created by AB InBev to unlock every grain of potential in our barley to impact people and the planet positively. EverPro is EverGrain's Upcycled Certified™, Non-GMO Project Verified barley protein, with market-

leading solubility and superior protein digestibility scores. Our in-house team of scientists, sustainability experts, nutritionists and product developers ensure we understand every molecule of barley, creating ingredients that improve plant-based foods and beverages' nutrition and environmental integrity.

Farbest Brands can help you meet the demand for clean label ingredients with a full range of high-quality dairy and plant proteins, gum acacia, ester gum, vitamins, sweeteners, natural colors, and USDA-certified organic and Non-GMO Project Verified ingredients. No matter your budget, application or label claim, we guide you to the ingredients that are right for you. With our extensive market knowledge and personalized customer service, we help our customers make better purchasing decisions. www.farbest.com/

IFPC partners with plant-based food and beverage manufacturers across the country, supplying quality ingredients, creating custom ingredient solutions and providing expert industry advice. Our in-house research and development team provides formulation assistance to help brands perfect the taste and texture of plant-based products. To learn more visit: https://ifpc.com/contact/

Idaho Milk Products continually produces the highest quality milk proteins and offers the best all-around service you deserve. Our vertical integration provides full lot traceability from the dairy to your facility. When tested by third-party trained panels, our dairy proteins consistently outperform competitor products in delivering superior solubility, texture, hydration, consistency and flavor. Our innovative IdaPlus products, calcium-reduced proteins are ideal for clean label, high-protein RTDs, yogurt, flavored milks, ice cream and replacing caseinates. https://www.idahomilkproducts.com/

At **Kerry**, we help nourish people, society and our planet with great-tasting, nutritious and sustainable solutions. Kerry has been a trusted protein supplier for 50 years, offering a range of specialty dairy and plant protein ingredients with high nutritional and functional ability. Using our market leading protein technology, application expertise, deep taste knowledge, and in-depth nutritional science capability, we partner with customers to create their perfect protein-rich products. https://www.kerry.com/

Lactalis Ingredients is an expert global manufacturer and supplier of a wide range of high-quality whey and dairy ingredients. These products bring superior functional and nutritional benefits for customers in the sports nutrition, active & healthy lifestyle, infant nutrition and food industries. Lactalis continues to pioneer the dairy industry with their latest initiative, UP2U®. It's the company's first direct-to-consumer sports nutrition brand highlighting Pronativ® in an unflavored native whey protein powder and protein sports drinks. https://www.lactalisingredients.com/

A leader in vital wheat gluten, starches, proteins and fiber, **Manildra's** stacked solutions ensure your products rise above the competition. Our GemPro line of wheat proteins provides the widest range of functionality available on the market. Through strength, extensibility, emulsification or solubility, GemPro proteins contribute unique texture and processing solutions in bakery, snacks, beverages and more. Our ingredients and service will meet yours and exceed your expectations. https://www.manildrausa.com/

Sensient Technologies Corporation is a leading global manufacturer and marketer of colors, flavors and other specialty ingredients. Sensient uses advanced technologies and robust global supply chain capabilities to develop specialized solutions for food and beverages and products that serve the pharmaceutical, nutraceutical, cosmetic and personal care industries. Sensient Flavors & Extracts innovative technologies offer optimal choices for complete flavor system development. https://sensientflavorsandextracts.com/

Vitalus Nutrition's passion is improving lives by unlocking the nutritional value of milk. We transform high-quality Canadian milk into specialized dairy ingredients, like milk protein concentrates and isolates, galacto-oligosaccharides and cream. Vitalus has grown from a small family-owned business to a trusted international supplier of specialty ingredients for large-scale processors and top-tier brands. Headquartered in Abbotsford, BC, with a second plant in Winnipeg, MB, Vitalus is ideally situated to access International and North American markets. https://vitalus.com/

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