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Next-Generation Proteins: Innovations Across Plants, Fermentation, and beyond

By Céline Schiff-Deb, CSO | MISTA

Executive Summary

This section provides a framework to understand emerging protein innovations explored during the MISTA Growth Hack on Healthy Nutrition. Driven by consumer demand for sustainable, functional, and flavorful protein solutions, multiple technology streams are reshaping the food landscape.

Plant proteins from **Ingredion**, **Alpine Bio**, **Harris Woolf Almonds**, **Plantible**, **Kyomei**, **SWAP**, and **Bettany** are produced to deliver purer, more functional ingredients that enhance taste and texture.

Biomass fermentation features new protein-rich ingredients grown from microorganisms, bacterial biomass by **Solar Foods**, **Air Protein**, **String Bio**, **Superbrewed**, **FermFood**; mycelium innovators such as **Koralo**, **Maia Farm**, **Sempera Organics**, **Essential Impact**, **Typcal**, and **Future Biome**, alongside microalgae producers **Nutrition From Water**, **Arborea**, and **FUL Foods**.

Precision fermentation companies—**Verley**, **Aux Labs**, **Turtle Tree**, **EVERY Company, Oobli, Geltor** and **Ten Lives**—focus on animal-free dairy and other functional proteins through bespoke microbial expression systems. Pharming players **Alpine Bio** and **Veloz Bio** engineer plants to express caseins and lactoferrin. Cultivated proteins represented by Wildtype expand cellular seafood applications.

Enabling technologies from **Amplifye**, **Shiru**, **Rivalz**, **Eat Curious**, **Buhler**, **Lasso**, **READYBAR**, and **RegUI8 CPG** strengthen formulation efficiency, digestibility, deliciousness, and scalability.

Collectively, these innovations signal a dynamic transition toward next-generation, health-forward protein systems and foods.

Proteins are essential for building and repairing tissues, including muscles, skin, and organs, making them a cornerstone of overall health and well-being. They also play a key role in the production of enzymes and hormones that regulate vital body functions. Because proteins can help increase satiety and support a healthy metabolism, they play an active role in weight management.

Modern consumers are increasingly aware of these benefits, and mega-trends such as the growing use of GLP-1 drugs and the pursuit of nutrient density are further fueling the attraction to high-protein foods, beverages, and supplements. As a result, food companies are adding more protein to products such as snacks, drinks, and plant-based alternatives to meet the growing demand for health and fitness.

But not all proteins are created equal. They can differ in their nutritional quality (e.g., essential amino acids, digestibility), as well as in their taste (e.g., beanie flavors), color (e.g., brown), and functional characteristics (e.g., solubility, emulsification properties, extrudability, etc.)

During the MISTA Growth Hack on Healthy Nutrition, over **35 types of proteins and their associated enabling technologies were collectively explored and assessed by the MISTA Ecosystem**. This section will provide a framework for thinking about various proteins based on their origins, as well as some insights into how they can be applied to healthy & delicious foods.

Plant Proteins	Biomass Fermentation	Precision Fermentation	Cultivated	Enablers
Alpine Bio, HWA, Kyomei, Ingredion, plantible, Eat Curious, SWAP, READYBAR	Bacteria: Bettani, String Bio, FERM FOOD, SUPERBREWED FOOD, air protein, SOLAR FOODS Fungi: SEMPERA ORGANICS, Maia, fotorTec, OPTIMIZED FOODS, typcal, essential, KORBIO Microalgae: NXW NUTRITION FROM WATER, ARBOREA Yeast: MOA FOODTECH, EQUII, revyve	VERLEY, EVERY, TurtleTree, GELTOR, Oobli Pharming: Alpine Bio, VELOZBIO, ten lives	WILDTYPE	amplifye, shiru, Lasso, BÜHLER, RIVALZ, RegUI

Framework of the main protein approaches explored during the MISTA Growth Hack for foods and beverages.

Animal-Derived Proteins

There is no denying that animal proteins are a pillar of the food chain. Globally, approximately 35% of dietary protein comes from animal-source foods (such as meat, dairy, eggs, and fish), and about 65% from plant sources. In high-income countries, the percentage of animal-derived protein is significantly higher, accounting for around 60% or more of total protein intake. Even in low-income countries, the share of animal-derived proteins is increasing. But as the world population continues to grow, the **need for additional sources of protein is becoming paramount.**

For this edition of the MISTA Growth Hack, we will focus solely on sources of protein not directly derived from animals (yes, there is a twist here - check out the Precision Fermentation section).

Plant Proteins

Plant proteins have been feeding the world for millennia, but with the advent of modern agriculture and new technologies (e.g., new varieties, improved farming practices, fertilization, and downstream processing), we are witnessing a new generation of **high-performance plant ingredients**. For example, **Ingredion's** array of protein ingredients allows for the concentration of proteins (>80% in their pea isolate vs. <25% in dried pea), while improving performance in food applications. **AlpineBio**, thanks to its proprietary processing technology, can produce next-generation, clean, fractionated soy protein isolate that supports functionality (high solubility) and reduces off-flavors in a white powder. Innovative approaches can also concentrate the proteins in nuts. **Harris Woolf Almonds** produces an almond protein powder with twice as much protein as the kernel (which is already packed with 20% protein), turning a snacking favorite into an even more versatile food ingredient. **READYBAR** takes advantage of the protein rich plant ingredient to deliver 1 BAR = 1 MEAL.

When discussing unusual sources of plant proteins, let's turn to **miniature plants**. Lemna, also known as duckweed, which is often mistaken for algae, is a free-floating aquatic plant that grows rapidly on the surface of still water in ponds, lakes, and slow-moving streams. **Plantible** is growing lemna in ponds and purifying a key enzyme in the photosynthesis process present in their leaves - RuBisCO - the most abundant natural enzyme on earth. This white protein is very nutritious (PDCAAS of 1, which represents the highest quality of protein, indicating that a protein source provides 100% or more of all the essential amino acids required in the diet and is highly digestible), and highly functional (gelling and foaming). **Kyomei** is also producing RuBisCO, by upcycling crop leaf waste (for example growing sugar beets produces 40% of leaf waste), thus reducing the CAPEX otherwise needed to grow the raw ingredients.

An example of plant protein-forward chicken fillet was served during the MISTA cocktail by Chef Phil Saneski. **SWAP** (previously Umiami) can create a whole-cut chicken breast using soy protein isolate and pea protein flour, eliminating the need for animal protein.

As a segue to the next category of proteins leveraging fermentation, we can take the example of **Bettany** (previously Climax Food). They combine a novel protein ingredient, naturally derived from the seeds of regenerative crops, with traditional cheese-making fermentation to deliver full-bodied, animal-free cheeses.

Biomass Fermentation

Biomass fermentation refers to the simple concept of growing microorganisms (yeast, fungi, microalgae, and bacteria) in industrial fermenters, harvesting these cells

(the biomass), and then removing some/all of the water. Voilà! You get a nutrient-rich ingredient, often naturally very concentrated in protein (some can naturally be over 80% protein per dry weight) and other key nutrients (fibers, fats, vitamins, etc.)

At MISTA, we are **bullish about Biomass Fermentation** to the point that the 2024 Growth Hack was entirely dedicated to this class of ingredients. In a nutshell, biomass fermentation has the potential to scale and deliver healthy proteins at a price comparable to traditional bulk ingredients. For more details, please refer to the article by Elaine Watson at AgFunder and to the special dossier detailing the 14 start-ups compiled by Protein Production Magazine (pages 74-90). In the 2025 editions, we further explored a dozen such ingredients.

Let's start with the **bacterium-derived ingredients**. Bacteria are already an integral part of our daily diets (think of the ferments in yogurts or most probiotics) and possess many excellent characteristics. To name a few: they produce a lot of proteins (concentrations of 60 to 80+% are common), often of very high nutritional quality (PDCAAS of 1), and can be industrially grown in a matter of hours. What's even more exciting is their ability to grow on different sources of nutrients (or feedstock). The ingredients produced by **Solar Foods** and **Air Protein** are actually manufactured by feeding carbon dioxide (CO_2) to cells, thereby converting a greenhouse gas into new sources of food. **String Bio**'s process can utilize methane, an even more potent greenhouse gas, as the source of carbon to grow its biomass. All these approaches result in different types of whole cell protein ingredients, varying in composition (albeit all protein-rich), color (some are pure white, others bright yellow), and functional characteristics. Another fascinating bacterial ingredient is produced by **Superbrewed**, using corn mash as a substrate, to deliver a white, tasteless, and highly functional, versatile ingredient. **FermFood** exemplifies another use of bacterial biomass. They essentially can take low-grade plant materials (grains, vegetables, etc.), seed them with bacteria, and let the microbe ferment and convert some of the plant substrate into a more complex matrix enriched in proteins, but also lactic acid (for natural preservation) and other nutrients, while decreasing some of the plant biomass's negative characteristics (e.g., beany flavor, antinutritional factors).

We also wanted to dive deeper into **mycelium**. Mycelium is the basic structure of mushrooms and fungi, and it can be obtained in various ways. To simplify, mycelium can be grown in tank-like fermenters, where cells grow as filaments in liquid culture over a matter of days and can then be harvested. They can also be grown on "solid" feedstocks (for example, some grains) and harvested in a more solid form. The ability of fungi to upcycle a variety of feedstocks (from rice hulls to chickpeas) and to develop their filament-like structure makes them excellent matrices for producing protein- and fiber-rich ingredients. Some technologies yield interesting fibrous properties that are beneficial for specific food applications, such as plant-based meats and fish (Koralo's mycelium and oceanic microalgae combo for full-cut fish; Maia Farm's oyster mushroom ingredients; Sempera Organics' Mamu, made from gourmet mushrooms, nutrient-dense mycelium, and fermented chickpeas).

Meanwhile, other form factors are better suited for applications requiring protein-rich flours (**Essential Impact's** low-cost mycelium produced in Kenya, **Typcal's** neutral mycelium powder made in Latin America). Other mycelium technologies detailed later in the report are more geared towards specific applications like the encapsulation of lipids (**Optimized Foods - HYfat**), salt reduction (**Fotortec**), or functional health benefits **(Koralo**, **Sempera Organic - Functional ingredients**, **Future Biome, Optimized Food** - Cocoa Koji).

The last class of biomass we explored is the **kingdom of microalgae**. Microalgae are unicellular, ancestral aquatic plants that are rich in proteins, nutrients, and pigments, and can be efficiently produced through fermentation. **Nutrition From Water** is growing a type of chlorella that contains 50% protein and can perform as a Marine Whey™ in multiple food applications. **Arborea** can efficiently produce a multitude of photosynthetic microalgae in their Biosolar Leaf™ "breathing cultivation system" - some of their ingredients are geared towards functional proteins, others to colors, and more nutritional applications. **FUL Foods** also relies on cyanobacteria for natural blue pigments (more on this later.)

Note that we did not dive into **yeast** ingredients in the 2025 edition, not because they are not interesting or do not deliver on performance, but because we explored several great technologies in the 2024 edition (**EQUII, Revyve, MOA Foodtech**).

Precision Fermentation.

This is the part where the molecular machinery of a microorganism (often a yeast or filamentous fungus) is hacked to produce a molecule of interest. In this section, we will focus on proteins. The idea of **reprogramming microorganisms' genetic information** to code for specific animal proteins has been a technical and commercial reality for decades (think about insulin production for diabetic patients or chymosin enzymes for cheesemaking).

Milk and **milk-derived ingredients** are highly nutritious (e.g., whey is beneficial for bodybuilders) and also highly functional (e.g., caseins make cheese stretch and melt). Recently, there has been growing interest in reducing our reliance on animals for ecological (e.g., greenhouse gas emissions), ethical (e.g., poor husbandry practices), and health reasons (e.g., antibiotic resistance). Enter companies that can produce highly pure milk proteins without the need for cows through microbial precision fermentation. **Verley** produces functionalized beta-lactoglobulin ingredients (the main protein in whey) that can be very soluble or have excellent coagulation properties. **Aux Labs** is producing functional caseins for protein-rich, meltable mozzarella cheese, in a low-cost, decentralized fashion. **Turtle Tree** has deployed this technology to produce a minor protein in milk (typically less than 0.05%), lactoferrin, which has numerous health benefits (see the next section).

Egg proteins are another class of proteins that are commonplace in many foodstuffs (bakery, ready meals, snacks, etc.) because of their PDCAAS score of 1 (egg is the "perfect protein") and their excellent food functionality (foaming, binding, gelling, etc.).

To learn more about the many benefits of eggs, go check out the **American Egg Board** website. Over the last few years, the egg supply chain has been disrupted by avian flu, which created price volatility. The food industry is exploring alternatives to mitigate the variation in egg availability. **The EVERY Company** has been working for years to commercialize several egg proteins produced through yeast fermentation - an ovalbumen ingredient that can perform all the functions of a traditional egg white protein, as well as a specialized egg protein selected for its superior solubility qualities.

Precision fermentation can also respond to the nutritional needs of pets. **Ten Lives** is developing a sustainable cat snack by "brewing animal proteins" by microbial fermentation - cats are obligate carnivores. Other companies are leveraging precision fermentation to make specialized proteins (**Oobli** for sweet proteins and **Geltor** for collagen), but you need to read on to further sections to have more details.

Pharming

Note that plants can also be used to produce specific animal or other proteins of interest (like the coveted milk proteins). The **plants are genetically programmed** to code for the target proteins that can be accumulated in various plant parts, and then further extracted and purified. **Alpine Bio** is leveraging the scalability of row crops to produce caseins and lactoferrin in soybeans. **Veloz Bio** is utilizing discarded fruits and vegetables to transiently produce caseins, eliminating the need to invest in CAPEX to build fermentation capabilities.

Cultivated

The term "cultivated meat" was adopted by the food industry around 2019 as the preferred nomenclature for meat grown from animal cells, in fermenters. After several years of hype and mushrooming of start-ups in the space, a few companies are now at a stage that allows them to **commercialize their products** - which means they can produce the animal cells at a relatively reasonable cost & they were awarded regulatory approval to sell (and serve). **Wildtype** is one of the few approved cultivated products on the US Market. During the Growth Hack Demo Day, 50 lucky participants were able to taste their delicious lox (smoked salmon).

Enablers

To round up this (long) section on proteins, let's spend a minute introducing technologies we like to call "enablers". This category is somewhat heterogeneous.

Let's start with **Amplifye** (formerly Digestiva). They have discovered a class of proteases (enzymes that digest proteins) that are activated only at very low pH levels (think acidic conditions found in the gut). The enzyme can be easily formulated with a wide range of foods, remains inert without affecting their taste or sensory properties, and only becomes activated in the consumer's digestive tract.

There, it becomes busy breaking down hard-to-digest plant proteins and releasing more amino acids into the bloodstream, thereby **increasing the digestibility** of plant proteins.

Yes, proteins can do many things, in addition to delivering nutrition. That is what **Shiru** is setting up to mine the huge diversity of natural proteins. They have developed an **AI platform** that can query their immense proprietary library that includes > 33 million protein sequences, against target functionality (e.g. gelling, binding, sweet taste, GLP-1 effect). Explore the fat section to learn more about one of their commercial products, which is derived from their platform. Many others are in their pipeline.

Now, let's take a look at technologies that can help proteins be more delicious to eat. One of these technologies is called **extrusion**. By very precisely applying set conditions of temperature and pressure delivered through very complex screws to plant and other sources of proteins, extrusion can help modify the tertiary structure of proteins, so they could unravel and form long strands (like for plant-based meat) or gain the ability to expand and become crunchy (like in puffed snacks.) At the MISTA Innovation Center, in San Francisco, we operate a **Buhler** machine (30mm, twin screw, dry and wet extrusion, if you want to know) in our Extrusion Hub. That's where we developed some of the snack concepts during this Growth Hack [see inset for details]. **Rivalz** is a healthy snack company that utilizes AI to refine a specific extrusion process, resulting in delicious puffed snacks with high protein and fiber content. **Eat Curious** commercializes extruded pulses as protein rich ingredients (dehydrated pieces or mince) and in finished food products.

MISTA Extruder Hub during the prototyping session of the Growth Hack 2025

Extrusion Insight

During the 2025 Growth Hack, we found out that microbial proteins can be used to make snacks with shockingly high protein levels (up to 15g per 1-ounce serving), as the proteins tend not to cross-link. While that might be undesirable for meat alternatives where we want to promote a meaty, chewy texture, it turned out to be an asset for these crispy & crunchy high-protein/fiber snacks. Note that Ingredion's starch and fiber ingredients were instrumental in the delivery of tasty puffs, in combination with these new protein sources.

Another technology leveraged during the 2025 Growth Hack is Buhler's high-capacity grain puffing technology. By taking whole grains such as quinoa, oats, chickpea, or spelt, they can be "popped" (like popcorn) using steam to achieve a unique, nutritious ingredient, for example, to add a crunchy texture to protein bars or to reduce cocoa and sugar in chocolate applications while increasing crispiness.

Another technology used to provide pleasurable texture to plant-based protein ingredients is fiber-spinning technology. **Lasso** (formerly Tender Foods) can produce meat-like shreds or crunchy crackers rich in proteins, leveraging centrifugal force to spin food ingredients into fibrous material with a unique texture.

Finally, it can be challenging to keep track of all these new ingredients, especially when creating new recipes and developing formulations. **RegUI8 CPG** is a software solution that can **assist food scientists in tracking their recipes, simulating a nutritional panel, providing ingredient declarations, and flagging the regulatory status of all** ingredients. Pretty handy, especially when making high-protein or high-fiber nutritional claims.

There are numerous transformational innovations on the protein front. We hope this section provides a framework for thinking about the various approaches and highlights some of the leading start-ups for each.