Institute on Science for Global Policy

# Toward a Diversified Protein Future**

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**Summary:** Global demand for high-quality, animal-sourced protein is expected to rise substantially in the coming decades as population grows and household incomes rise. Simultaneously, climate experts are calling for a rapid transition away from animal-derived foods in an effort to curb greenhouse gas emissions from animal agriculture. There is a global need for innovative solutions to produce quality protein without contributing to the negative environmental impacts associated with industrial animal agriculture.

**Current realities:** Currently, the world's highest-quality proteins come from animal products and have been shown to provide important defense against malnutrition and stunting, especially in the developing world. Among animal-sourced proteins, dairy is the most bioavailable in the human diet. Global demand for dairy protein is projected to increase 60% by 2050 as global incomes rise and the population grows to over 9 billion. Unfortunately, many people cannot afford to buy food that contains dairy protein, are unable to consume it because of milk protein allergies or lactose intolerance, or choose to restrict their consumption of dairy products. Additionally, dairy's reliance on animal agriculture poses a serious challenge to sustainability by burdening land and water resources already in high demand.

In light of these realities, many consumers are choosing dairy alternatives derived from plants. However, these products are of a much lower nutritional quality than animal proteins, as indicated by the Protein Digestibility Corrected Amino Acid Score and the Digestible Indispensable Amino Acid Score. In addition, plant-based products do not have the same taste, texture, and functional properties of dairy products. As a result, plant proteins alone are ill-equipped to address the global challenge. There is no obvious solution for consumers who want the nutritional value and sensory experience of dairy without the animal welfare concerns or negative environmental impacts associated with its production.

**Scientifically credible approaches and challenges:** Advances in biotechnology provide unique opportunities to address current and foreseeable nutrition needs, without the significant environmental and climate impacts caused by animal agriculture. Processes using microflora encoded with genes to produce specific proteins are an important example. *Microflora* refers both to the plants of a specific region, as well as microorganisms collectively. Here, *flora* is a shorthand way to refer to the fungi, yeast, bacteria, and other organisms commonly used to produce ingredients via fermentation.

Of specific commercial interest are the dairy proteins casein and whey, which are produced in microflora by Perfect Day. Microflora are grown in fermentation tanks with a sugar feedstock to produce flora-based protein that is chemically and nutritionally equivalent to its farmed bovine counterpart. The protein is then separated and purified via filtration and dried into a powder. This fermentation process is similar to those widely employed by the food industry to produce ingredients such as vitamins, amino acids, enzymes, and natural flavors. Protein made using this approach enables dairy products to have the same great taste and texture as their conventional counterparts. No hormones or antibiotics are used, and lactose (i.e., milk sugar) is not present. The latter is especially noteworthy in that this technology allows people who are lactose-intolerant—approximately 70% of the world's adult population—to consume flora-based dairy products without digestive issues.

Additionally, microflora can be harnessed to produce high-demand food products with much lower environmental impact based on land and water use, greenhouse gas emissions, and energy consumption. Because the fundamental biology is analogous to protein production in animals,

but without the wasteful step of producing live animals and their associated pollutants, flora enable "doing more with less." Further, while farm animal yields have begun to hit diminishing returns, there is rich opportunity for flora to become more efficient with future advances in biotechnology. For example, while currently, the most common fermentation feedstock for microflora is sugar obtained from commodity crops, the industry is developing the ability to use carbon sources that today have no appreciable commercial value (e.g., crop residue). This would render flora-based protein production more sustainable and better adhere to the principles of a circular economy.

As ingredients, flora-based proteins easily fit into the existing production infrastructure and business-to-business supply chain dynamic of the global food industry. This is critical because new technologies can only address the global challenge if they can be proliferated to the same extent as animal-sourced proteins. An approach based on flora is inherently flexible; in theory, any biological product could be produced at-scale using standard processes and capital equipment, enabling flora to address growing demand across all types of protein. The potential economic opportunities are huge, both in valorizing existing facilities and in establishing new ones to expand global production. Additionally, since fermentation is feasible in any climate or geography, flora can bring protein independence to regions that currently import the majority of their protein. However, renovating and building new infrastructure is costly. Realizing the profound nutritional and environmental benefits of this technology will require global investment from both public and private entities in capital-intensive fermentation and separations capacity.

**Evidence-based options and real-world opportunities:** Creating a new category of products requires consumer education. Given increasing consumer skepticism toward food technology, it may be especially difficult for consumers to understand how flora-based products are made and what benefits they provide. Consumers seek transparency from food manufacturers but many are wary of foods developed through genetic engineering, despite rigorous exonerating safety data. The challenge for companies like Perfect Day is twofold: (i) build trust with consumers through transparency about biotech's processes and potential benefits and (ii) compete with existing products in a media zeitgeist that values simplicity and familiarity over scientific fact. A clear description of the protein production process and the safety credentials of biotech foods will help provide safety reassurance. Early research has indicated that, for most people, the benefits of such technologies outweigh the concerns. Still, the constraints of labeling could hurt the consumer appeal of flora-based products and encumber their adoption into the food system.

Clear labeling that accurately informs consumers is essential to communicate the non-animal origin of the protein, while differentiating from plant-sourced proteins. More critically, labeling needs to alert consumers to potential allergen risks. As an example, the well-known allergen risks of milk are shared by flora-based dairy proteins since they are chemically the same as proteins from cow's milk. Thus, it is imperative to clearly label on-package that these products contain a milk allergen, a responsibility that may challenge the regulatory paradigm that prohibits Perfect Day from using the word "milk."

Given the many perceived oxymorons, unique terminology is necessary to describe this new type of protein, its production, and the food products made from it. New terminology must avoid being confusing or misleading and must adequately differentiate fermentation-derived protein from that derived from either plants or animals. The term "plant-based" fails to distinguish the new approach from plants, while phrases like "synthetic" or "lab-made" are virtually guaranteed to hinder consumer interest in this space. Vague words like "clean" or "green" appear to push a marketing agenda. The ideal terminology would be rooted in science so that it can be adopted in official contexts. As a pioneer in the field, Perfect Day has invested in identifying and assessing a wide variety of potential category names to address these many constraints and has arrived at the term "flora-based." To assess the clarity of this phrase in a fermentation context, Perfect Day

commissioned a national survey with adults aged 21-60; 79% of respondents concluded that "flora-based dairy" accurately describes this new type of dairy. When asked how well the phrase "flora-based dairy products" helps them differentiate between this new source of dairy and conventional dairy, 77% said that it differentiates "very well" or "somewhat well."

Perfect Day is pioneering flora-based proteins for use in dairy applications, but it is critical to anticipate a world where similar processes are used to produce different kinds of flora-based food ingredients. The same approach could be used to manufacture fully designed novel proteins, in a transition that would mirror the development of the synthetic materials industry.

There is broad consensus for the need to increase protein production to meet global demand for optimal nutrition without further straining the planet's resources. With support from national and international regulatory bodies, flora-based protein has the potential to help fill the gap. To move toward a diversified protein future, specific actions must be considered:

- For finished products made with fermentation-derived protein from bioengineered microorganisms, develop labeling to allow a simple modifier such as "flora-based" (e.g., flora-based milk, flora-based frozen dessert). There is precedent for labeling food that does not meet the relevant standard by using a modifier to distinguish it from the standardized food (e.g., "yogurt drinks" and "frozen yogurt" are not subject to the standard of identity of "yogurt," and a vegan product may be labeled "mayo" if it bears the term "spread and dressing" to distinguish it from standard mayonnaise). Similarly, U.S. federal courts have held that "almond milk" and "soy milk" are appropriate names for beverages since they have an appropriate modifier to distinguish from "cow's milk."
- Ensure the allergen risks are appropriately communicated in labeling standards and guidelines for foods containing these new proteins.
- Because the proteins developed by Perfect Day are chemically the same as conventional casein and whey, label such products as "non-animal casein" and "non-animal whey protein." Such labeling accurately inform consumers that the casein and whey in flora-based foods are the same as those used in traditional foods, but are not derived from cow's milk.
- The requirements underlying the current Food and Drug Administration (FDA) Generally Recognized As Safe (GRAS) notification process provide a navigable path to ensure the safety of novel foods and ingredients in the U.S. Adopt a similar process in European markets to lower the barrier for emerging companies.
- Support commercialization of flora-based ingredients through partnerships at the federal, state, and local levels to enhance production capacity. Specifically, investment is needed to construct production facilities at a scale that will enable flora-based products to make a significant contribution to the world's staggeringly large protein industries.

**References:**

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