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From protein transition to food systems transition: Dairy's holistic role in sustainable food systems

Highlights

- The so-called "protein transition" lacks a coherent definition and is shaped by a diverse range of stakeholder interests and values. It generally involves a shift away from animal source to alternative-origin protein.
- "Protein transition", with its singular focus on protein, risks causing unintended health consequences, including micronutrient deficiencies.
- A shift beyond a narrow focus on "protein transition" toward a holistic food systems focus is needed — one that integrates nutritional, environmental, economic, and social dimensions to support sustainable healthy diets.
- Dairy contributes to sustainable food systems by providing essential and affordable nutrients, supporting rural livelihoods, preserving cultural heritage and reducing environmental impact through innovative farming practices.

Origins and development of the "protein transition" paradigm

The concept "protein transition" does not have a single agreed-upon definition and is understood in different ways by different stakeholders (Pyett et al., 2023). Duluins and Baret (2024) conducted a systematic review of studies published from 2011 to 2022 to explore the meaning of "protein transition". The article showed that to most, "protein transition" means a shift from a diet rich in animal proteins to one richer in alternative-origin proteins. However, it also showed that views on the "protein transition" differ regarding its association with reducing total protein intake or replacement of animal proteins with alternative sources. Alternative proteins included protein sources from plants, algae, fungi, insects, and single-cell proteins.

The attention on protein is not new. From the early 1950s to the early 1970s, childhood protein malnutrition was seen as the most pressing global public health concern. However, by 1974, many had come to view the so-called "protein gap" as overstated (LeBlanc, 2023), recognizing that globally there is no protein shortage (Fletcher et al., 2024) and that micronutrient deficiencies are of much greater concern (Smith et al., 2021).

The renewed focus on protein stems from the rising protein demand and concerns over a potential protein deficit for a growing global population. This has heightened attention to identifying a sustainable protein supply. The concept of "protein transition" emerged in response to environmental pressures linked to current food production and consumption patterns, particularly those involving animal source foods (Fouillet et al., 2023).

The mean dietary animal: plant (A:P) protein ratio is around 60:40 in high-income countries (Drewnowski & Hooker, 2025). While some countries strongly favored plant-based diets that include animal source foods, specific targets for reducing A:P protein ratios are being promoted in many high-income countries. For instance, the Health Council of the Netherlands has proposed an A:P protein ratio of 40:60 for consideration by the Dutch government, without highlighting the potential trade-offs on essential nutrients (Health Council of the Netherlands, 2023), similarly to the Flemish Green Deal Protein Shift (Flanders Research Institute for Agriculture, Fisheries and Food, 2024). Efforts to promote plant-based eating are also under way in Germany, Sweden, Norway and the United Kingdom (Safe Food Advocacy Europe, 2020), as well as other high-income countries such as Canada. On the global scale, the EAT-Lancet Planetary Health Diet has proposed an A:P protein ratio of approximately 30:70, with most of the dietary protein coming from grains, root crops, pulses, nuts and seeds (Willett, et al. 2019). However, this dietary model has been challenged for its inability to ensure nutrient adequacy across diverse populations and life stages (Beal et al., 2023).

What is the impact of the "protein transition"?

The concept of "protein transition" has attracted significant attention from some governments, researchers, media and civil society. This has started to influence dietary guidelines, leading to policy recommendations in some countries that seek a reduction in animal source foods in favor of plant source foods or plant proteins.

While the intention behind "protein transition" is mainly to mitigate environmental impact and perceived health benefits, it often fails to consider the full spectrum of health and nutrition impacts, including the intake of essential amino acids, micronutrient bioavailability, and overall dietary adequacy across diverse population groups. Stanton (2024) showed how dramatic reductions in consumption of animal source foods, entailed by many plant-based diets, could worsen already prevalent micronutrient and protein deficiencies. This concern is often overlooked, particularly in high-income settings where the "protein transition" framework is most commonly promoted. While it is essential to address the severe nutrition challenges in low-income countries, it is equally important to underscore the widespread nutrient inadequacies in high-income countries. Moreover, the "protein transition" is also

unsuited in other regions where diets are particularly nutritionally inadequate and already lack sufficient animal protein intake (Food and Agriculture Organization of the United Nations [FAO], 2018a). The framework also ignores the vulnerable populations, including children, pregnant women and older adults who have higher nutritional needs.

Simply replacing dairy protein with plant protein can result in a lower overall protein quality (Witard et al., 2025). Protein quality is a critical factor in caloric efficiency. Lower-quality proteins, typically from plant sources, offer fewer essential amino acids per calorie and are less digestible (Phillips, 2017; Van Vliet et al., 2015). Meeting amino acid requirements with these proteins often requires a greater intake of total protein and thus, more food, which can cause macronutrient imbalances or require increased food intake, thus more calories. This has implications for energy balance, particularly in diets aiming to preserve lean mass or manage weight (Moughan et al., 2024).

The primary challenge that "protein transition" aims to address is reducing the environmental footprint of protein production and consumption (Duluins and Baret, 2024). However, the current approach focusing on reduction of animal source protein does not seem to yield the intended results. For example, in a European study modeling the substitution of animal source protein with plant source protein within a circular food system, Simon et al. (2024) found that the most substantial reductions in land use and greenhouse gas emissions were not achieved by altering protein ratios but by optimizing, for example, dietary patterns; cultivation methods such as increased legume production; and animal husbandry through, for example, dairy products from upcycling of inedible biomass such as grass and by-products. Furthermore, Huppertz et al. (2025) showed that reducing dairy did not significantly affect environmental outcomes but did increase prices. This result suggests that the products required to fill the nutrient gaps left by dairy elimination have comparable environmental impacts but are more expensive.

The holistic narrative: From "protein transition" to food systems transition

Protein is a vital macronutrient for human health, but reducing nutrition to a single nutrient overlooks the diversity of protein sources and their complex nutritional interactions (Witard et al., 2025). This reductionist view overlooks both the synergy between nutrients, known as the food matrix, which significantly influences health outcomes (Weaver & Givens, 2025) as well as the fact that protein sources provide more than protein alone. More protein-rich foods deliver a diverse pack of nutrients (vitamins and minerals) to the diet and food system.

Instead of focusing solely on the narrative of replacing or reducing animal protein, the future health and wellbeing of global populations would benefit shifting towards a holistic narrative about food systems transition that balances various pillars described below while considering local contexts and needs.

The FAO defines a sustainable food system as a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised (FAO, 2018b). From this definition, the concept of sustainable healthy diets emerges (see Box 1).

Successful food system transitions must integrate all four pillars—nutrition and health, environmental, economy and social- rather than focusing solely on protein sources. Promoting diverse diets that incorporate both nutrient-dense animal source foods and plant source foods can achieve better health outcomes meeting essential nutrient needs to support healthy growth, development, and aging across vulnerable stages of the life cycle while advancing sustainability goals (Beal et al., 2024).

BOX 1

According to FAO & the World Health Organization (2019), sustainable healthy diets are dietary patterns that promote all dimensions of individuals' health and wellbeing; have low environmental pressure and impact; are accessible, affordable, safe and equitable; and are culturally acceptable. The aim of sustainable healthy diets are to achieve optimal growth and development of all individuals and support functioning and physical, mental, and social wellbeing at all life stages for present and future generations; contribute to preventing all forms of malnutrition (i.e. undernutrition, micronutrient deficiency, overweight and obesity); reduce the risk of diet-related non-communicable diseases; and support the preservation of biodiversity and planetary health. Sustainable healthy diets must combine all the dimensions of sustainability to avoid unintended consequences. Additionally, in line with the United Nations Sustainable Development Goal 2, the FAO has defined a new indicator for healthy eating, namely the minimum dietary diversity factor (FAO, 2025). This framework recommends ten essential food groups, which includes dairy, to overcome hunger and ensure adequate nutrient intake. This holistic approach also acknowledges the role of animal foods as part of a diverse and nutritious diet.

The role of dairy in sustainable food systems

→ Nutritional and health considerations

Dairy products are a key part of balanced diets due to their high-quality protein and bioavailability of key nutrients such as calcium, vitamins B2 and B12, and iodine. They are also rich in magnesium, potassium, and various fatty acids (FAO, 2013). Dairy offers high nutrient bioavailability and absorption and replacing dairy with plant source foods may compromise nutrient intake, leading to potential deficiencies in calcium and vitamin B12 (Leonard et al., 2024). Also, regular consumption of dairy is linked to lower risks of non-communicable diseases such as osteoporosis, cardiovascular disease, type 2 diabetes and colorectal cancer (Drouin-Chartier et al., 2016; Giosuè et al., 2022; Wallace et al., 2020, Zhao et al., 2021). These beneficial effects are not solely due to the presence of isolated nutrients but are attributed to the unique dairy matrix, which enhances nutrient bioavailability and synergistic interactions that support overall health (Mulet-Cabero et al., 2024).

→ Environmental considerations

The environmental footprint of dairy varies across production systems, presenting opportunities to enhance sustainability though tailored efficiency improvements. Innovative

practices — including better feed efficiency, animal health, and manure management — have reduced greenhouse gas emissions per unit of dairy product (FAO and GDP, 2018). Dairy also supports circular agriculture by using crop byproducts as feed and enhancing soil health through grass-clover cultivation and organic manure (Hoogstra et al., 2023). Many dairy systems convert non-edible feed materials into high-quality food and operate on land unsuitable for crops (Mottet et al., 2017). Well-managed dairy systems further promote biodiversity and carbon sequestration through practices like covered cropping, soil health improvements, and sustainable land management which can be adapted to various environmental contexts, including areas where pasture-based systems are not feasible year-round.

→ Economic and livelihood considerations

The dairy sector is also fundamental to the livelihoods of millions of farmers, especially in rural communities. In low- and middle-income countries, dairy farming supports household income and provides food security (FAO, et al. 2018); dairy processors also contribute to food security and help generate additional employment at the processing sector level. In high-income regions, dairy farming likewise plays a key role in rural incomes while dairy cooperatives and processors play a pivotal role in stabilizing the agricultural economy and sustaining rural development.

Furthermore, dairy products are a widely available, affordable, nutrient-dense food source, providing critical nutrition, particularly for populations with limited access to diverse diets and vulnerable populations at risk of nutrient inadequacy. (Drewnowski, 2010; Hess et al., 2019)

→ Cultural and social considerations

Food is tightly woven into culture, and changing food consumption patterns inevitably means altering cultural traditions and identities. Dairy holds significant cultural and social value in many regions, forming a staple in traditional diets and food practices. Its cultural integration and widespread acceptance make dairy more than just a nutrient source; it represents a socially important food that supports dietary diversity and cultural heritage (Eriksson, 2022; Khalil et al., 2023).

Conclusion

The “protein transition” narrative oversimplifies sustainable food systems by focusing solely on reducing animal protein, while neglecting other critical nutrients essential for human wellbeing, such as vitamins and minerals. A shift toward a more inclusive, systems-based approach is needed — one that integrates health, environmental, economic and cultural considerations. Sustainable innovations like feed optimization, methane mitigation and regenerative agriculture are already improving the environmental performance of animal source foods, including dairy. Recognizing these advancements supports a more balanced, evidence-based transition where diverse food sources contribute to both global nutrition and environmental sustainability goals.

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