

VIEWPOINT

Can Plant-Based Meat Alternatives Be Part of a Healthy and Sustainable Diet?

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Diets high in red meat, especially processed meat, have been associated with a wide range of health consequences including obesity, type 2 diabetes, cardiovascular disease, and some cancers. Based on a comprehensive review of epidemiologic evidence, the International Agency for Research on Cancer of the World Health Organization classified processed meats such as hot dogs, bacon, and sausages as carcinogenic to humans for colorectal cancer, and unprocessed red meats, such as beef and pork, as "probably carcinogenic."¹ In addition, there is growing concern that industrial meat production can contaminate natural resources, including rivers, streams, and drinking water, with nutrients from animal waste lagoons and runoff. There is also concern that the raising of livestock can lead to the loss of forests and other lands that provide valuable carbon sinks as well as the large amounts of greenhouse gas emissions that contribute to the ongoing environmental and climate-related issues.²

It is clear that for both human health and the health of natural resources and the planet, a sustainable food system that shifts the global population toward more plant-based foods and less animal-based foods is needed.³ Dietary patterns predominant in minimally

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processed fruits, vegetables, whole grains, nuts, soy, and other legumes have been recommended to improve human health and environmental sustainability. In the meantime, a variety of plant-based food products have been developed to replace those traditionally made from animals. These products include both dairy alternatives (eg, soy and nut "milks") and meat alternatives in the form of burgers, sausages, and other meat-like products made from largely processed plant-based components. Although these products provide more plant-based alternatives to animal foods, they are not necessarily intended to mimic the actual sensory experience of consuming meat.

A new generation of plant-based meat alternatives (PBMA) has entered the market. These products are specifically designed to mimic the taste and experience of eating meat, while being marketed as a way to accelerate the shift away from animal-based products. But should PBMA be considered part of a healthy low-carbon diet

(one that aims to reduce greenhouse gases due to the methods of production, packaging, processing, transport, preparation, and waste of food) that can help reduce reliance on industrial meat production? The answer to that question remains far from clear given the lack of rigorously designed, independently funded studies.

At this point, 2 companies dominate the PBMA landscape. Impossible Foods and Beyond Meat both offer burger patties, which are now available in numerous fast food restaurant chains, supermarkets, and other food entities primarily in North America. Designed to imitate the taste and experience of eating meat, these novel products are aimed to appeal to a broader consumer base than the relatively smaller vegan or vegetarian demographic that had more often been the target of earlier animal product alternatives.

For their touted climate and natural resource benefits and their unique mimicry of meat, PBMA have garnered significant consumer attention. A recent Life Cycle Assessment commissioned by Beyond Meat found that the Beyond Burger generates 90% less greenhouse gas emissions and requires 46% less energy, 99% less water, and 93% less land use compared with a burger made from US beef,⁴ leading to the conclusion that PBMA are likely to have less environmental effects than industrial beef production based on the metrics analyzed. However, the robustness of this conclusion warrants further studies.

While environmental factors can and should be strong motivators of food choice, it is equally important to consider the effects of PBMA on human health. It is important to be cautious in directly extrapolating the potential benefits found in previous research on plant-based foods and dietary patterns to PBMA, given their highly processed nature. Randomized clinical trials have demonstrated that replacing red meat with nuts, legumes, and other plant-based protein foods reduces levels of total and low-density lipoprotein cholesterol.⁵ Long-term epidemiologic studies have also shown that this shift from red meat to plant foods is associated with lower risks of chronic diseases and total mortality.⁶ However, PBMA incorporate purified plant protein rather than whole foods, with Beyond Burgers using pea protein isolate and Impossible Burgers using soy protein isolate and concentrate. A recent short-term controlled feeding study found that consuming diets high in ultra-processed food causes excess caloric intake and weight gain.⁷ Beyond the creation of calorically dense and highly palatable products, food processing can also lead to the loss of some nutrients and phytochemicals naturally present in plant foods.

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While Beyond Meat and Impossible Foods burger patties are lower in total and saturated fat than a beef burger patty and contain zero cholesterol (they are similar in calories and protein), they are also both higher in sodium. Without further studies, there is no evidence to substantiate that these nutrient differences alone offer a significant health benefit. In fact, PBMA are higher in saturated fat compared with most minimally processed plant-based protein sources, such as beans and lentils.

When assessing the health effects of PBMA it is also necessary to consider how these products are consumed. For example, these popular PBMA burgers are often consumed in fast food settings where they may be placed on a refined grain bun with an array of toppings, served with french fries and even a sugary beverage. Thus, it is not possible to assume that substituting a PBMA patty for a beef patty improves overall diet quality.

In addition, another concern that is unique to the Impossible Burger must be considered. This product contains high amounts of heme (an iron-containing molecule) from soy plants added to the burger patty to enhance the product's meaty flavor and appearance. Higher intake of heme iron has been associated with increased body iron stores and elevated risk of developing type 2 diabetes.⁸

To address questions about the health effects of PBMA and the role PBMA can play in a low-carbon sustainable diet, rigorously designed, independently funded studies are needed. Although it is not feasible to conduct large long-term trials on disease outcomes, short-term intervention trials can be conducted to compare the effects of these products with conventional animal products and minimally processed plant protein sources on cardiometabolic risk and other factors such as the microbiome. In addition, both intervention and observational studies should be conducted to examine how the consumption of PBMA influences individuals' overall diet quality, caloric intake, nutrient status, and body weight. Moreover, at the population level it will be important to examine whether an increase in the consumption of PBMA actually leads to a significant reduction in red meat intake.

One major challenge in studying meat alternatives is that their formulations and nutrient contents may change quickly due to rapid technological innovations and product reformulations. Although

burger patties and other red meat replacements may be the most widely available products to date, other PBMA are either being introduced or developed, including those mimicking poultry or fish. Another line of products on the horizon is laboratory-grown (or cultured) meat, poultry, and fish, which uses cell-based technologies to culture and grow cells from animals, producing animal products without raising and slaughtering the animal. While all or some of these meat alternative technologies could represent a significant opportunity to reduce greenhouse gases that fuel climate change, they also may represent a major disruption in food systems, agriculture, and fisheries, which could have important public health, environmental, and regulatory implications.

Although red meat consumption in the United States declined steadily for decades and has remained stable in recent years, it has increased sharply worldwide, especially in lower- and middle-income countries.² The global demand for meat, much like energy needs, will continue to increase in the coming decades. In parallel with rapid nutrition transition, the global burden of obesity and diet-related chronic diseases has been rising considerably. PBMA may have some role in improving human and planetary health, but there is no evidence to suggest that they can substitute for healthy diets focused on minimally processed plant foods. Nutrition policies and dietary guidelines should continue to emphasize a diet rich in plant-based foods such as nuts, seeds, and legumes or pulses, which are rich in protein and many other nutrients but require little industrial processing. More traditional options such as tofu, seitan, and tempeh can be also used to diversify meat alternatives. But ultimately a fundamental change in the food system requires policies and actions that create a culture in which healthy and sustainable food choices are accessible, affordable, enjoyable, and the norm.

To meet the unprecedented challenge of feeding a healthy and sustainable diet to an estimated 10 billion people by 2050, recent reports recommend a substantial reduction in red meat consumption and shifting toward mostly plant-based dietary patterns.³⁻⁹ Technological innovations are vital to creating this system, but it will be important to remain vigilant to ensure that these new products are beneficial to human health as well as the health of the planet, and to understand and consider any unintended consequences.

ARTICLE INFORMATION

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