Trends and Opportunities in the Global Plant-Based Meat Industry

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ABSTRACT

Producing meat-like products directly from plants instead of animals creates significant gains in production and market efficiencies. Emerging innovation in plant-based meat shows promise for revolutionizing the food system, and global growth in the plant-based meat industry has exploded over the past few years. Identifying the most important white space ideas, prioritizing the research needed to explore them, and solving related technical issues across the entire value chain—from crop development to foodservice and retail distribution—constitute the highest impact strategies for enabling plant-based meat to help supply the global demand for meat. Four areas in need of additional research and development are crop optimization specifically for plant-based meat formulations, alternative manufacturing methods, expanded production capacity, and product sensory improvements. If successfully implemented on a global scale, a food system with a much greater reliance on plant-based meat-like products has the potential to sustainably feed 9.7 billion people by 2050 and mitigate climate change and other pressing environmental problems. Furthermore, inappropriate use of antibiotics in food animals contributes to antimicrobial resistance, and it is estimated that three of four new or emerging infectious diseases in humans are transmitted from animals. Thus, modernizing meat production by reducing use of animals in the food system can decrease the risk of global public health issues such as antibiotic resistance and zoonotic threats.

As the world population expands and countries become wealthier, the already high global demand for animal protein continues to increase. To meet this growing demand, the food system requires large-scale, industrialized methods of raising farm animals for food. Although modern food production is vastly more efficient than 100 years ago, industrialized animal agriculture still suffers from both market and production inefficiencies (8). If animals are thought of as biofactories for transforming plant matter into animal protein, animals are processing plant nutrients into meat at only 3–11% efficiency (7). Any industrial process with such high rates of inefficiencies is ripe for disruption.

Processing plant ingredients into meat analogues without using animals can be done more efficiently. For example, producing a plant-based burger instead of a beef burger cuts greenhouse gas emissions by 30–90%, reduces water use by 72–98%, mitigates 51–94% of potential water pollution, and uses 47–99% less land (1). The term "plant-based meat" is used to refer to plant-based products designed to replace animal meat. This includes products that replicate the taste and texture of meat, as well as products made from plants (such as jackfruit, seitan, tofu, and tempeh) that serve as functional meat replacements. Although fungi and algae are not biologically classified as plants, fungi- and algae-based products are included in this definition of plant-based meat.

Global growth in the plant-based meat industry has exploded over the past few years. Hundreds of plant-based meat startups have been launched in countries as varied as Brazil, China, India, Israel, the Netherlands, and the United States. Many established food and agribusiness companies are launching plant-based product lines, and hundreds of millions of investment dollars are pouring into the plant-based meat space. Plant-based meat products have started popping up on global menus in the United Kingdom, Europe, Israel, Canada, and the United States in restaurant chains such as McDonald's, Burger King, Starbucks, Qdoba, and Dunkin' Donuts. The NPD Group reports that in the United States foodservice sales of plant-based meat grew 37% in 2019 (13). Plant-based burgers now have a 3.4% market share in the fast food sector (12). U.S. retail sales of plant-based meat were US$939 million in 2019, growing 18% year-over-year—more than six times faster than animal meat and accounting for 2% of retail packaged meat sales (10). Similar trends are occurring in other regions of the world, with the European Union seeing a 15% compound annual growth rate (CAGR) for alternative proteins (6) and China experiencing about 14% year-over-year growth in its domestic plant-based meat industry (9).

Plant-based foods appeal to a wide variety of consumers for many reasons. Personal health, taste, environmental sustainability, and animal welfare are primary motivators for eating more plant-based foods (11). Most plant-based meat consumers are omnivores who gravitate toward plant-based meat products that mimic the sensory experience of animal meat without the health and sustainability drawbacks. Globally, plant-based meat consumption is highly correlated with flexitarianism as consumers increasingly look to reduce (but not eliminate) animal meat consumption. In the United States, two-thirds of consumers are seeking to reduce their consumption of at least one type of meat (5). Even in Brazil, which has a deeply ingrained culture of animal meat consumption, approximately one in three consumers is looking to reduce their consumption of animal products (3). Producing plant-based meat with optimized taste, texture, and other sensory qualities, cleaner ingredient decks (formulas), and affordable prices is key to tapping into pent-up consumer demand. Plant ingredient innovation and supply chain optimization are logical starting points for unlocking necessary product improvements.

There are several reasons to encourage utilization of cereal grains in plant-based meat. Many cereals are produced globally

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at a fairly large scale and are familiar crops that already form the foundation of diets around the world. Additionally, cereal proteins can be incorporated successfully into plant-based meat products. Recent research demonstrated that zein, a protein found in corn, created a fibrous texture similar to chicken when integrated into a soy-based meat prototype (4). Wheat has been, and continues to be, used as the protein source for more traditional plant-based products like seitan, as well as newer "2.0" products, due to the ability of wheat protein (gluten) to be texturized. Texturization is the process of converting plant proteins from their usual globular state into more elongated fibers that mimic the structure of animal muscle proteins and help create a meat-like eating experience. Although wheat and soy are expected to remain widely used as plant-based meat inputs, many producers have embraced other proteins, such as pea, potato, chickpea, quinoa, and rice, to avoid consumer allergenicity concerns and to take advantage of the functional benefits of other plant proteins.

Despite exciting advancements in plant-based meat development, the ultimate success of this industry, and the role cereals will play in it, depends heavily on continued research and technological developments. The amino acid profiles and protein levels of cereal grains are currently suboptimal for plant-based meat applications, and cereals generally lack the environmental benefits of crops like pulses that can naturally fix nitrogen. Breeding cereal crops specifically for plant-based meat formulations may overcome some of these limitations, and developing ingredient blends that combine proteins from multiple cereals or cereals and pulses may create advantageous nutritional and functional characteristics.

Turning crops into ingredients for plant-based meat is not a trivial process, and research focused on ingredient optimization is critically needed. Generally, producers favor ingredients that are as inexpensive and versatile as possible. A plant protein that is odorless, colorless, tasteless, and easy to texturize may represent a cost savings if it can replace an ingredient that has an off-putting flavor, fragrance, or color notes and requires additional additives to modulate undesirable characteristics. Because many plant-based meat products are texturized via extrusion, a manufacturing process that involves many variables, plant-based meat manufacturing is often a sophisticated combination of art and science. Feedback loops between input and process variables are poorly understood, making homogeneity, purity, and consistency of ingredients from batch-to-batch and lot-to-lot of utmost importance.

Accumulating technological–functional data on plant-derived ingredients from a wider variety of crops for use in plant-based meat formulations should generate data that can be used to develop predictive analytics. The creation of computational methods to predict how changes in plant protein ingredient inputs manifest in finished products will reduce the amount of time and resources spent on trial-and-error formulation. This, in turn, should help streamline the ability of manufacturers to design a variety of plant-based meat and seafood products and tailor product types and flavor profiles to distinct geographic regions. Additional white space opportunities exist for improving supply chain scale and efficiencies, potentially by utilizing these ingredients and, thereby, adding value to existing agricultural sidestreams.

Plant-based meat represents a tremendously profitable market opportunity and offers substantial promise for addressing the urgent challenges facing the global food supply. Scientists and entrepreneurs will play a critical role in advancing the quality, price, and availability of plant-based meat, positioning it as an economically viable and efficient source of protein. If successfully implemented on a global scale, a food system with a much greater reliance on plant-based meat has the potential to sustainably feed 9.7 billion people by 2050 and mitigate climate change and other pressing environmental problems. Furthermore, the United Nations General Assembly has identified inappropriate use of antibiotics in food animals as a leading cause of antimicrobial resistance (14), and the U.S. Centers for Disease Control and Prevention estimates three of four new or emerging infectious diseases in humans come from animals (2). Thus, modernizing meat production by reducing use of animals in the food system can decrease the risk of global public health issues such as antibiotic resistance and zoonotic threats.

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