Plant-based meat replacement products: an overview

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Abstract. Plant-based meat replacement products have emerged as popular alternatives to traditional animal meats, driven by concerns about health, environmental sustainability, and animal welfare. These products aim to replicate the taste, texture, and nutritional profile of animal-derived meat using plant-based ingredients like legumes, soy, and grains. Key components include protein sources, fats, binders, texturizers, and flavorings. Technological processes such as protein extraction, texturization, and flavor development are critical to producing these meat analogs. While they offer benefits like lower cholesterol and reduced environmental impact, challenges such as cost, nutritional content, sensory perception, and regulatory issues remain. The market continues to grow, supported by consumer awareness and product innovation. Future directions include improving flavor and texture, expanding the product range, improving sustainability and reducing the degree of industrial processing.

Key Words: plant-based meat, sustainability, meat alternatives, food technology, nutritional profile, consumer trends, food innovation, environmental impact.

Introduction. Plant-based meat replacement products have gained significant attention in recent years as alternatives to traditional animal meat (Szenderak et al 2022). These products are designed to mimic the taste, texture, appearance, and nutritional profile of animal-derived meat using plant-derived ingredients. The primary motivations behind the development and consumption of plant-based meats include health benefits, environmental sustainability, and ethical concerns regarding animal welfare (Bryant 2022). In 2022, the global plant-based meat market size was valued at USD 6.7 billion and will reach USD 35.1 billion by 2032 (Figure 1) (Market.US 2023).

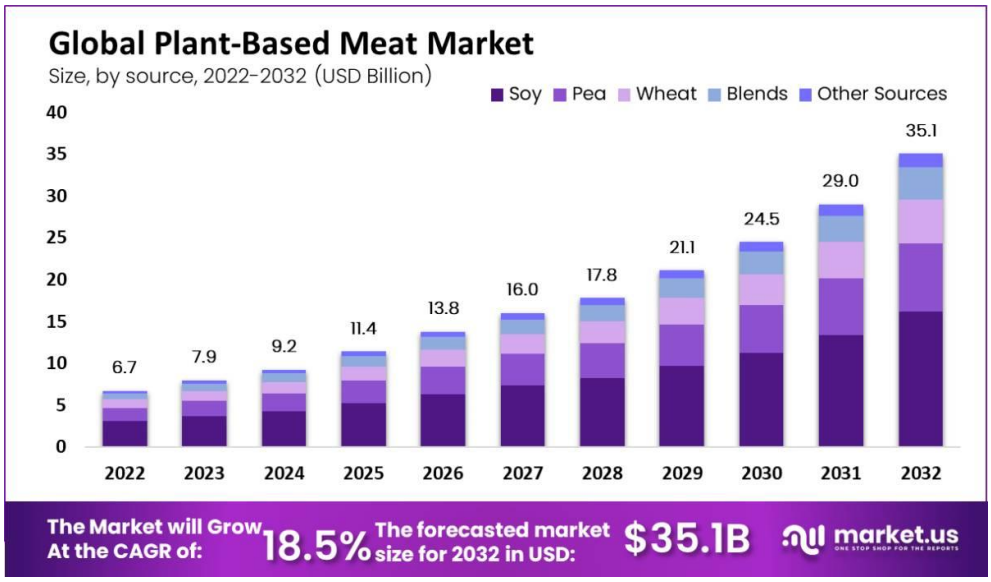

Figure 1. The global plant-based meat market size (https://market.us/report/plant-based-meat-market/).

Ingredients and composition. The key ingredients in plant-based meat products often include the following ingredients (Ahmad et al 2022).
Protein sources. Legumes - Pea protein is a common ingredient, as it provides a high-quality protein profile compared to other vegetal products (Romão et al 2023). Soy - Soy protein isolate is frequently used for its complete amino acid profile and functional properties (Kyriakopoulou et al 2021). Grains and seeds - Wheat gluten (seitan) and other grains like rice or oats can also be used for protein (Romão et al 2023).
Fats. Coconut Oil - Provides a similar mouthfeel to animal fat (Kyriakopoulou et al 2021). Canola Oil - Often used for its neutral flavor and healthier fat profile (Kyriakopoulou et al 2021).
Binders and texturizers. Methylcellulose - Used for binding and texture. Starches and Gums - Such as potato starch or guar gum, to improve texture (Kyriakopoulou et al 2021; Romão et al 2023).
Flavorings and colorings. Natural Flavors - Yeast extracts and spices for flavor enhancement. Beet Juice Extract - Used for a red color that mimics raw meat (Kyriakopoulou et al 2021).

Technological processes. The production of plant-based meats involves several key processes (Kyriakopoulou et al 2021).
Protein extraction and isolation. Proteins are extracted from plants and isolated to create a concentrated protein base.
Texturization. Using methods like extrusion cooking, proteins are texturized to replicate the fibrous structure of meat.
Flavor and aroma development. Through the use of natural flavors and fermentation processes, products achieve a meaty taste.
Assembly and formulation. Ingredients are combined and formed into final products, such as burgers, sausages, or nuggets.

Nutritional profile. Plant-based meats are often formulated to match as much as possible the nutritional content of their animal-based counterparts. Key nutritional aspects include the followings.
Protein content. Close to meat protein content, but in many cases low protein content is observed (Romão et al 2023).
Fat and caloric content. Meat substitutes present similar total and saturated fat content compared to their animal-based counterparts (Romão et al 2023). The results of Romão et al (2023) showed that meat substitutes commonly present lower energy values and higher amounts of carbohydrates and dietary fiber.
Vitamins and minerals. Many products are fortified with nutrients commonly found in meat, such as vitamin B12, iron, and zinc, but in many cases the producers do not show the content in Vitamin B12, iron, and zinc (Romão et al 2023).

Health implications
Pros. Plant-based meat products are similar in saturated fat content compared to their animal-based counterparts (Romão et al 2023), but they are cholesterol-free and often higher in fiber, depending on the product (Harnack et al 2022). They are potentially lower in calories, aiding in weight management (Romão et al 2023).
Cons. Many plant-based products are high in sodium (Harnack et al 2022; Romão et al 2023) or contain additives like preservatives. Sometimes they are ultra-processed (Khandpur et al 2021).
Not all plant-based proteins offer the complete amino acid profile found in animal proteins, although blending different plant proteins can address this issue. The protein concentration is sometimes lower than that of meat products (Harnack et al 2022). Replacing red meat with high-quality plant sources has been shown to improve the profile of risk factors associated with cardiovascular disease, like total cholesterol and LDL (Khandpur et al 2021). However, these benefits do not extend to replacements of red meat with low-quality carbohydrates that are plant-based (Guasch-Ferré et al 2019).

Plant-based meat alternative products generally contain less zinc, iron and vitamin B12 than animal meats (Harnack et al 2022; Romão et al 2023).

Environmental impact
Pros. Reduced Greenhouse Gas Emissions: Plant-based meat production generates fewer emissions compared to traditional livestock farming (Tilman & Clark 2014). Lower Land and Water Use: Requires less land and water, reducing the strain on natural resources (Tilman & Clark 2014). Biodiversity Conservation: Reduces the need for deforestation and habitat destruction associated with livestock farming (Van Vliet et al 2020).
Cons. The massive adoption of the vegan diet through regulations or taxes on the livestock sector would endanger many breeds of animals, which would disappear like the breeds of draft horses that disappeared with the advent of mechanization (Petrescu-Mag 2022). Even in the context of animal breed conservation programs, they would go through bottlenecks and genetic drift, which would radically and negatively change the gene pool of animal breeds. That would mean a huge loss for biodiversity (Petrescu-Mag 2022).

Market and consumer trends. The market for plant-based meats is expanding rapidly, driven by some factors.
Consumer awareness. Increased awareness of health, environmental, and ethical issues.
Product innovation. Improved taste, texture, and variety of products.
Retail and foodservice adoption. Availability in supermarkets and restaurants has increased accessibility.

Challenges
Cost. Plant-based meats can be more expensive than traditional meat (Pais et al 2020).
Sensory perception. Achieving the exact taste and texture of meat remains a challenge (Sucapane et al 2021).
Regulatory and labeling issues. As the market grows, there is increasing scrutiny over labeling and marketing claims.

Future directions
Research and development in flavor and texture. Ongoing research to improve sensory qualities and diversify product offerings (Sucapane et al 2021).
Expansion beyond meat substitutes. Incorporation of plant-based ingredients in a wider range of food products.
Sustainability innovations. Development of even more sustainable production methods, such as using less processed ingredients or more sustainable crops (Romão et al 2023).

Conclusions. Plant-based meat replacements are a promising innovation in the food industry, offering a more sustainable alternative to traditional meat. As technology and consumer acceptance continue to evolve, these products are likely to play a significant role in the future of food. Future directions include improving flavor and texture, expanding the product range, improving sustainability and reducing the degree of industrial processing.

Conflict of interest. The authors declare no conflict of interest.

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