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Handbook of Plant-Based Food and Drinks Design

Andreani, Giulia; Banovic, M.; Dagevos, H.; Sogari, Giovanni

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Chapter 25

Consumer perceptions and market analysis of plant-based foods: A global perspective

Giulia Andreani[1], Marija Banovic[2], Hans Dagevos[3] and Giovanni Sogari[1]

[1]*Department of Food and Drug, University of Parma, Parma, Italy,* [2]*Department of Management School Business and Social Science, MAPP Centre, Aarhus University, Denmark,* [3]*Wageningen Economic Research, Wageningen University and Research, the Hague, The Netherlands*

Chapter Outline

25.1 Introduction

Nowadays, there is a growing interest in the environmental, ethical, and health effects of our food choices (McClements & Grossmann, 2021), and a global transition toward sustainable diets has been promoted at both national and international levels to lower the impact of our eating habits. In order to attract interest and sensitize stakeholders, many events and educational campaigns have been implemented over the past decade, and the concept of "sustainable diets" has become an integral part of governments' priorities (Jones et al., 2016).

Sustainable and healthy diets have been defined by the Food and Agriculture Organization (FAO) as "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" (WHO and FAO, 2019). By reading this definition, we are distinctly dealing with a comprehensive concept that covers an umbrella of different aspects. There is no "silver bullet" to achieve the goals outlined by the FAO, and a lot of effort is required from several actors and sectors of the food system. Among possible solutions, shifting social norms toward plant-based diets—which do not require to permanently abolish meat—and away from the overconsumption of foods of animal origin is a key element (FAO, 2022).

Why is it necessary to reduce animal-based food consumption? The challenge of feeding a projected world population of nearly 10 billion people by 2050 along with the growing demand for meat products in industrialized countries is alarming if we consider the competition for agricultural land and resources (de Bakker & Dagevos, 2012; FAO, 2017). The industrial livestock sector is a relatively unsustainable process and is responsible for many environmental issues, such as deforestation, pollution, and biodiversity loss; in addition, animal products have a higher environmental impact per calorie (or gram) than most plant-based foods do (Aiking, 2011; Godfray et al., 2018). Along with these ecological aspects, food of animal origin is associated with animal welfare concerns (Godfray et al., 2018; Marescotti et al., 2020)

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and with increasing awareness among consumers regarding unethical practices of factory farming, including pigtail docking, poultry debeaking, calves' separation, and mistreatment in slaughterhouses (Grandin, 2018; Profeta, Baune, Smetana, Broucke, Van Royen, Weiss, Hieke, et al., 2021). Finally, animal products lead to an increased risk of non-communicable diseases (NCDs), such as cardiovascular diseases, cancer, diabetes, and obesity (Godfray et al., 2018; Willett et al., 2019). Current estimates show that the global adoption of a low-meat diet (and not necessarily a meat-free diet) that covers nutritional recommendations for fruits, vegetables, and caloric requirements is estimated to lower diet-related greenhouse gas emissions by nearly 50% and reduce premature mortality by nearly 20% (Barnard & Leroy, 2020; Bryant, 2022).

These data could be a solid driver for many consumers to reduce their consumption of foods of animal origin. However, many individuals still require and desire the specific appearance, flavor, texture, and feeling associated with animal products (Anusha Siddiqui et al., 2022). These sensory elements, along with the growing importance of adopting plant-based diets, have led to propelling advancements in the plant-based alternatives industry, with the development of several plant-based substitutes mimicking animal products (FAO, 2022; McClements & Grossmann, 2021). During the last decade, plant-based dairy and meat alternatives have become quite popular and widespread in various regions of the world (Andreani et al., 2023). More recently, plant-based options for eggs and seafood are also gaining attention and spreading in the global market (Boukid et al., 2022; Rondoni, Millan, et al., 2021).

Although the market of plant-based food has show impressive growth figures in recent years—as highlighted in the following sections of this chapter—it remains a fraction compared with the size of the meat and dairy markets—markets that are also projected to keep on growing in the near future (OECD, 2022; Parlasca & Qaim, 2022). Moreover, recent studies hint that plant-based foods are first and foremost complementary to conventional animal products rather than competitive and threatening to meat and dairy market shares (Andreani et al., 2023; Neuhofer & Lusk, 2022; Tonsor et al., 2023).

To provide a comprehensive picture of the current role of consumers in the plant-based alternative sector, this chapter investigates the current knowledge on consumers' perception of several types of plant-based foods (i.e., meat alternatives, hybrid meat, dairy alternatives, and egg and seafood analogs) and the latest market trends of these products.

25.2 Why do people choose to reduce animal-based foods? A general perspective

Although the landmark study *Livestock's long shadow* was almost completely focused on meat production in its modest attention to the demand side, it already highlighted—more than a decade and a half ago—that a consumer segment was reducing its meat intake due to "growing concerns about health, the environment, ethical, animal welfare and development issues" (Steinfeld et al., 2006). This early observation summarizes what scholarly work has extensively corroborated about the most relevant consumer concerns motivating dietary shifts away from (excessive) meat consumption. In other words, the question raised in the title of this section could be simply answered with the quoted phrase of Steinfeld and colleagues.

Multiple motivations can shape consumers' demand, including sociodemographic factors (e.g., income, age, sex), food product characteristics (e.g., price, safety, convenience, sensory properties, appearance, freshness, nutritional values), cultural aspects (e.g., social norms, eating conventions and traditions, religious beliefs), as well as human health considerations, environmental issues, and animal ethics. Strikingly, the last three (i.e., human health, environmental concerns, and animal welfare) are the foremost reasons why consumers choose to reduce the consumption of foods of animal origin and limit or abstain from eating meat. It has been consistently shown that ethical considerations about environmental sustainability and agricultural animal welfare, as well as reasons related to personal health, are important and common consumer motives to (intend to) limit the quantity of meat consumed and/or restrict the frequency of eating meat (Cooney, 2014; Hanras et al., 2022). Meat disgust is another identified reason to avoid or curtail meat that may count as an animal welfare-derived motive, whereas weight control could be considered a health-derived reason to cut down on meat (Hopwood et al., 2021). Generally, consumer motives to reduce the intake of food of animal origin are on par with the broad agreement in academia that consuming less meat and dairy products benefits the environment, human health, and animal welfare. Hence, the main line that can be drawn in the research domain of meat-reducing (flexitarian) and meat-avoiding (vegetarian/vegan − hereafter: veg*n) food styles is clear: ecological impacts, health concerns, and ethical aspects of animal-based products are pivotal to answering the question on why contemporary Western food consumers limit their meat consumption, restrict their intake of animal-sourced products, or even entirely refrain from eating food of animal origin (Kemper et al., 2023; Müssig et al., 2022; North et al., 2021).

However, research on this topic continues, and the latest available scientific knowledge gains in detail and differentiation. This resonates in linking different categories of motivations to specific dietary positions. Food consumers have several motivations for engaging in meat reduction behaviors; for instance, ethical concerns about agricultural animals are strong motives for veg*n(s) to adopt and maintain a meat-free diet in comparison to flexitarians, whereas taste- and health-related product characteristics of plant-based foods are more relevant to flexitarians when reducing their intake of animal-based food products (Hopwood et al., 2021; North et al., 2021). A recent research project (Smart Protein Project, 2021) showed that, for flexitarians, the five most crucial motives to opt for plant-based foods were all product-related (i.e., taste, health, fresh, no additives, and cheap, respectively). Environmental sustainability (sixth place) and animal welfare concerns (seventh place) followed as minor factors that influence flexitarians' choices for plant-based foods. By the same token, omnivores' behaviors are more likely driven by egocentric motives, such as price, convenience, product familiarity, and personal health, whereas veg*n(s) are motivated by ecocentric elements in which the perceived benefits or costs of behavioral consequences to the ecosystem are of decisive importance (Boukid, 2021; Hanras et al., 2022; Müssig et al., 2022; North et al., 2021). Nevertheless, ethically and environmental-sustainability-oriented veg*n(s) can also be distinguished from personal health-motivated veg*n(s) (Cooney, 2014; Leenaert, 2017). Closer scrutiny in the field of flexitarianism reveals that—also within the heterogeneous dietary group of flexitarians—different motives prevail for different segments. Committed meat reducers—"heavy" flexitarians or "semi-vegetarians," to borrow a term from earlier research—are close to meat abstainers and share strong motivators with meat-avoiding consumers for rejecting meat: health benefits, environmental concerns, and animal welfare considerations are the main drivers. On the other end of the spectrum, avid meat eaters and flexitarian fractions that are more attached to meat consumption indicate that affordability (price), safety, and sensory appeal (taste) are driving motivations when considering reducing food of animal origin (Verain & Dagevos, 2022; Verain, Dagevos & Jaspers, 2022) compared with (Kemper et al., 2023; Malek & Umberger, 2021; Malek & Umberger, 2021; Malek & Umberger, 2023; Spendrup & Hovmalm, 2022).

Although recent studies—as the ones just mentioned—indicate that a segment of today's food consumers is uninterested in or indifferent to plant-based alternatives, minority groups of veg*n(s) and the emerging segment of flexitarians may be considered the main target groups of plant-based alternative products (Andreani et al., 2023; Dagevos, 2021; Lehto et al., 2023) if only for the simple reason that their meat-free/low-meat diets are facilitated by plant-based foods as affordable, accessible, appealing, and nutritious options to animal-based counterparts.

25.3 Market trends of plant-based alternatives

The market of plant-based protein alternatives has grown rapidly since the beginning of the 21st century, with the global plant-based food market expected to reach 77.8 billion U.S. dollars in 2025 and double by 2030 (Wunsch, 2022d). Impossible Foods Inc. (Redwood City, CA, USA), with The Impossible Burger, and Beyond Meat Inc. (El Segundo, CA, USA), with the Beyond Burger, are among the first companies gaining popularity in this sector thanks to their successful products mimicking beef burgers (van der Weele et al., 2019). More recently, other large companies (e.g., Tyson, Perdue Farms, Nestlé, and JBS) have also joined this promising market (Morach et al., 2021; Sha & Xiong, 2020).

To analyze the latest trends, this section explores the data on new plant-based alternatives retrieved from Mintel's Global New Product Database (GNPD) (Solis, 2016). This online tool allows researchers to review and analyze information about new product activities on the market. Data were extracted in February 2023 based on the following search strategy:

- The *Category* matches one or more of: "Processed Fish, Meat & Egg Products"; "Dairy."
- The *Date Published* is within the last five complete years (i.e., 2018−22).
- The *Claim* matches one or more of: "Plant-Based"; "Vegan/No Animal Ingredients."
- The *Launch Type* matches "New Product."

The research returned 5904 new plant-based alternative products launched on the global market over the 2018−22 period. Data were downloaded as an Excel file, and the results of the analysis carried out by the authors are presented hereinafter.

The nearly 5900 new launches extracted from GNPD refer to products designed to imitate food of animal origin in taste, texture, smell, and appearance and can be in the form of meat, dairy, fish, or egg analogs. More than half of these new product launches were dairy substitutes (62%), followed by meat (35%), seafood (2%), and egg (1%) alternatives.

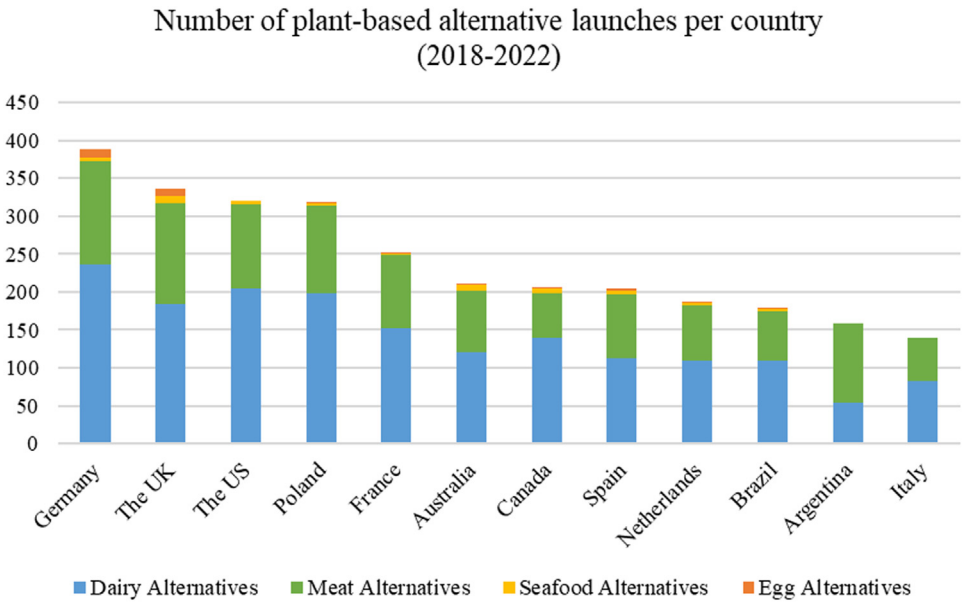

FIGURE 25.1 Twelve most active countries involved in the launches of plant-based alternatives over the 2018–22 period.

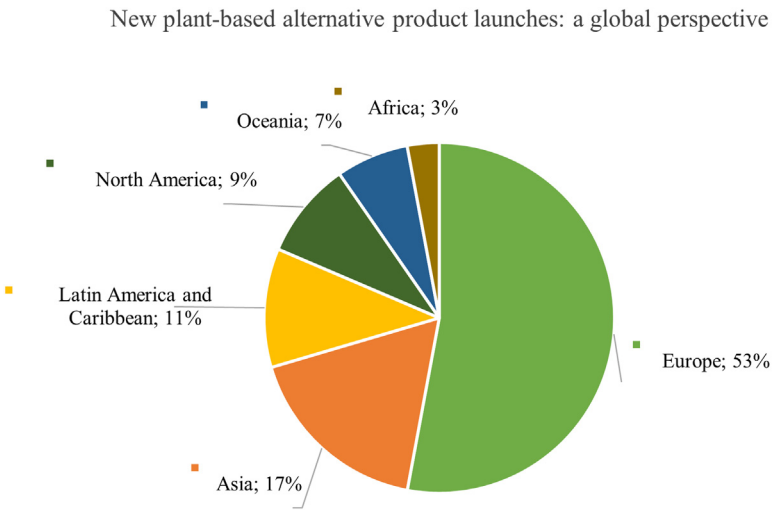

FIGURE 25.2 Distribution of geographic regions involved in the launches of plant-based alternatives over the 2018–22 period.[1]

The most involved countries in this sector are European countries, with Germany, the United Kingdom, Poland, and France as leading actors, along with the United States (Fig. 25.1). A general overview of the global market is represented in Fig. 25.2, which depicts that Europe and Asia together account for nearly 70% of the global launches of plant-based analogs over the 2018–22 period.

Considering these launches of new plant-based alternatives, dairy substitutes have an average price of 14.96 €/kg, and the preservation method mostly employed is either chilled or shelf stable. Meat analogs, which are usually sold frozen or chilled—but in some cases can also be shelf-stable (e.g., canned products) —have an average price of

1. Note, Figure 25.2: Africa = Algeria, Cameron, Morocco, Egypt, Ethiopia, Ghana, Ivory Coast, Kenya, Nigeria, South Africa, Tanzania, and Tunisia; Asia = Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Israel, Japan, Jordan, Kuwait, Laos, Lebanon, Myanmar, Oman, Pakistan, Philippines, Puerto Rico, Qatar, Saudi Arabia, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, Turkey, UAE, and Vietnam; Europe = Austria, Belgium, Belarus, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Holland, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the UK; Latin America And Caribbean = Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Mexico, Panama, Peru, and Venezuela; North America = Canada and the US; Oceania = Australia, Malaysia, and New Zealand. For the geographical division, please refer to: https://unstats.un.org/unsd/methodology/m49/.

23.07 €/kg. Egg and seafood alternatives are the most and second-most expensive categories, with 35.10 and 32.96 €/kg, respectively. Whereas seafood analogs are sold frozen (54%), chilled (25%), or shelf-stable (21%), egg substitutes are rarely sold frozen (<1%). To have a graphical representation of the preservation method, please refer to Fig. 25.3.

One relevant aspect for both consumers and manufacturers when considering the market of plant-based foods is the ingredients used in the production process. As we are dealing with products that should be high in protein, it is no coincidence that soy is the leading source of plant-based food ingredients, usually followed by rice, oat, and pea proteins. As a matter of fact, in 2020, sales of plant-based food employing soy as the main source were valued at nearly 2.4 billion U.S. dollars, and it is expected to grow and reach 4.1 billion U.S. dollars by 2026 (Wunsch, 2022a,c). Referring to the four food categories separately (i.e., dairy, meat, seafood, and egg alternatives), proteins derived from oat, soy, and rice are mostly used in dairy alternatives, whereas soy, pea, and wheat proteins are frequently used in meat and seafood analogs. As for egg alternatives, chickpea proteins are the most commonly used. A more detailed overview of frequently used ingredients as the main protein source is represented in Fig. 25.4.

The recent success of plant-based alternatives, and their positive market trends, also draws attention to a critical aspect that can influence consumers' food choices: the way these products are labeled. Even if it is not in the scope of the chapter, it is worth mentioning that labeling and product names are critical elements when considering consumers' perceptions and motivations (Asioli et al., 2023; Demartini et al., 2022). Preferences for shopping behaviors appear to be related to preferences for the labeling of plant-based alternatives; specifically, consumers who are inclined to prefer foods of animal origins over plant-based substitutes would usually allow the use of animal-sounding names (e.g., "beef" or "steak") only on animal products (Van Loo et al., 2020). Marshall et al. (2022) showed that, for meat-free dishes, consumers preferred meat-related names (e.g., cauliflower steak) over non-meat-sounding labels (e.g., cauliflower slice). If we focus on the current legislative situation in the European Union (EU), many stakeholders are demanding governmental interventions to regulate the labeling system of novel foods (Amato et al., 2023; Demartini et al., 2022). Since 2017, the Court of Justice of the European Union does not allow the market of plant-based dairy substitutes with designations such as "milk," "cream," "butter," "cheese," or "yogurt," which are reserved by the EU law for animal products only (Court of Justice of the European Union, 2017). The same legislation does not apply to products mimicking meat or other categories, for which no official law is currently in place at the EU level. As a matter of fact, the adoption of animal-sounding names—for example, "vegan burger" or "plant-based bacon" —is a major debating point when considering the sector of plant-based alternatives. Producers' and consumers' associations are discussing opposite

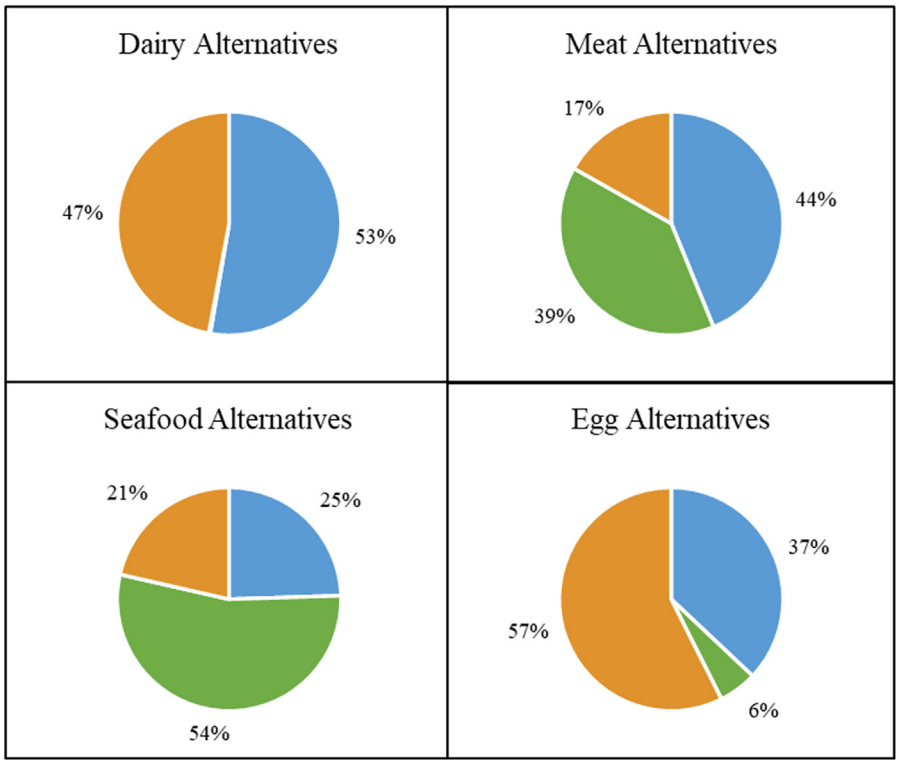

FIGURE 25.3 Preservation methods of plant-based alternatives launched over the 2018–22 period. Note: Orange = shelf-stable; Blue = chilled; Green = frozen.

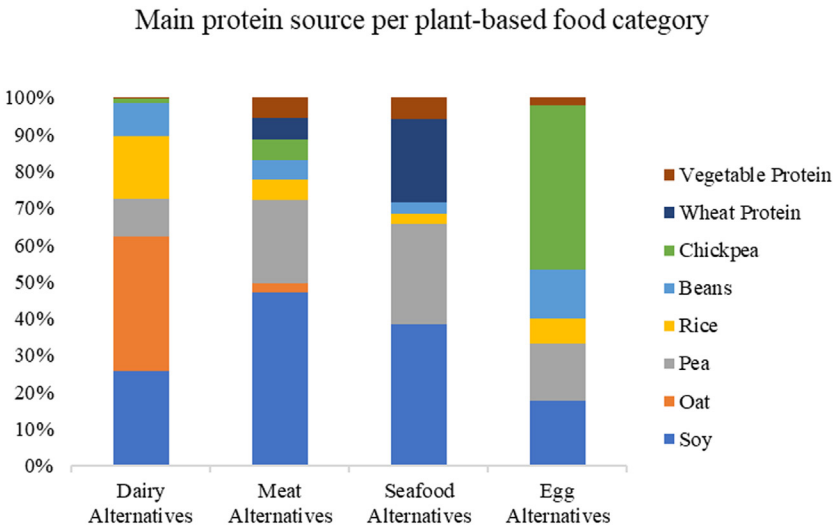

FIGURE 25.4 Top-8 most employed ingredient as the main protein source for the new plant-based alternatives launched over the 2018–22 period divided by category.

views at global levels, and the intervention of regulators is needed to solve this issue. However, different rules apply in different countries. For instance, in 2018, the French government outlawed the use of animal-related terminologies to describe plant-based foods (Assemblée Nationalite, 2018). On the other hand, the draft guidance of the Food and Drug Administration (FDA) "Labeling of Plant-based Milk Alternatives and Voluntary Nutrient Statements: Guidance for Industry" suggests that plant-based milk alternative products that mention the term "milk" in their name (e.g., "almond milk"), and that have a nutrient composition that differs from traditional milk, include a voluntary statement that conveys how the product nutritionally differs from animal milk (e.g., "Contains lower amounts of Vitamin D and calcium than milk") (Food and Drug Administration, 2023). Therefore, a unique view on how to label plant-based products that mimic animal-based foods does not exist yet. Further research should focus on testing possible solutions to protect both consumers and producers and reach harmonized guidance that could provide consumers with clear labeling and give them the information needed to make informed purchasing decisions.

While the dispute on how to label these products is still under discussion, the increased awareness of sustainable and health concerns is shifting consumer interests toward plant-based lifestyles, and consequently, manufacturers are employing claims on food packaging to capture consumers' attention. It is no surprise that the number of new packaged goods launched with a "plant-based" claim has grown by nearly 700% over the 2015–21 period and accounted for around 12% of 2021 total launches. If we focus the attention on the new product launches that are the subject of this section (plant-based alternative launches over the 2018–22 period), the five most employed claims are "Plant-Based," "Low/No/Reduced Allergen," "Vegan/No Animal Ingredients," "High/Added Protein," and an ethical claim to stress an environmentally friendly package. When considering single categories, claims mostly differ for dairy substitutes—that is, "Dairy Free," "Low/No/Reduced Lactose," and "Vitamin fortified"—which stresses the importance of being products suitable for lactose-intolerant consumers other than for individuals who seek plant-based options.

Finally, advancements in food technologies on the one hand, and increasing consumer concerns about health and climate change on the other, have fueled the global plant-based food market to reach a remarkable spike worldwide. Future growth is also expected (Andreani et al., 2023; OECD, FAO, 2022). Within the context of this projection, the next sections highlight strengths and weaknesses when it comes to consumers' preferences and sensory evaluation of plant-based product alternatives.

25.4 Consumer perception of plant-based alternatives

25.4.1 Consumer perception and sensory evaluation of meat alternatives

Nowadays, several plant-based meat alternatives containing either pulse- or cereal-based proteins have been developed and introduced into food markets to either fully replace meat (Andreani et al., 2023; Boukid, 2021) or combine animal- and non-animal-based ingredients, that is, the so-called "hybrid meat products" (Grasso & Jaworska, 2020).

Use of plant-derived protein products, such as tofu and tempeh from soybeans, has been a traditional practice for centuries in Asian countries. However, these products are not considered meat alternatives (Andreani et al., 2023; Giacalone et al., 2022), and due to their sensory differences compared with meat, they have not become popular in Western countries, especially among meat eaters (Fiorentini et al., 2020). For this reason, during the past years, the food industry has focused on developing meat-like substitutes that could mimic the sensory characteristics of animal products (Giacalone et al., 2022). Barone et al. (2021) employed online focus groups to cocreate healthier new meat products. Results showed that partial meat substitution with plant-based ingredients could be accepted by consumers when these products resemble regular meat in terms of sensory features, especially in their flavor.

Today, the terms plant-based "meat alternatives" and "meat analogs" typically indicate a new generation of products that try to imitate the taste, texture, odor, flavor, and appearance of processed meat, such as burgers, patties, sausages, and nuggets (He et al., 2020; Sha & Xiong, 2020). To reach these specific high-quality characteristics (e.g., "the bleeding burger"), various colorants—such as leghemoglobin, red beets, and red cabbage—are used in the production process of meat alternatives (Andreani et al., 2023). These and other elements (e.g., vegetable oils) contribute to a long list of unfamiliar ingredients (Cutroneo et al., 2022) that could lead consumers to perceive the product as unnatural (Hartmann et al., 2022).

Given that low sensory appreciation, especially for taste and appearance, is a strong barrier to the adoption of meat substitutes (Giacalone et al., 2022), and considering the crucial role of ingredients in modifying these aspects (Banovic and Sveinsdóttir, 2021), sensory attributes and overall consumer acceptance are strongly influenced by the types of plant protein sources used in the production process (Caputo et al., 2023; Lemken et al., 2019). For instance, some legume proteins can negatively influence the sensory characteristics of meat analogs by providing the final product with a beany off-flavor (Sogari et al., 2023).

The most investigated meat category in consumer studies, including sensory tests, is burgers (Andreani et al., 2023; Michel et al., 2021; Onwezen et al., 2022; Slade, 2018); however, little is known about consumers' sensory evaluation of plant-based meat products (Fiorentini et al., 2020; Martin et al., 2021). The first consumer and sensory tasting studies focused on the "first generation" of plant-based foods—that is, not specifically developed to mimic foods of animal origin (Caparros Megido et al., 2016; Schouteten et al., 2016). More recently, some studies investigated the "new generation" of meat analogs (Grasso et al., 2022; Smetana et al., 2021; Sogari et al., 2023) and tested the impact of information provision (e.g., "conventional 100% beef burger" vs "plant-based" or "hybrid" burger) on consumers' perception and sensory evaluation. Results showed that respondents generally prefer traditional meat products over their plant-based counterparts. Interestingly, Grasso et al. (2022) found that—both under blind and informed conditions—hybrid burgers were the most appreciated ones, followed by beef and plant-based burgers. Focusing on plant-based options, the texture was a critical aspect under the blind condition, followed by the taste, aroma, and appearance. Nevertheless, these attributes significantly increased in liking, especially for appearance and taste, in the informed condition.

Another sensory study, one of the few using pork meat substitutes, evaluated the role of information (health and environmental benefits of using plant proteins) on consumer preferences for a plant-based sausage. Results showed that information (both health- and environmental-related) significantly increased the purchase intention for the plant-based option. However, consumers' higher preference for traditional pork sausages was not reversed, even after providing the information (Martin et al., 2021). These results suggest that the no-conventional sensory attributes of plant-based meat alternatives are more easily accepted when the information about its characteristics is disclosed; however, this impact is not strong enough to overturn consumers' preferences, which remain in favor of traditional meat food (Cordelle et al., 2022; Grasso et al., 2022; Martin et al., 2021).

In line with previous results, studies exploring consumer responses toward plant-based meat burgers in terms of demand changes (i.e., purchasing behaviors) indicated that individuals usually prefer traditional meat products (Caputo et al., 2023; Profeta, Baune, Smetana, Broucke, Van Royen, Weiss, Heinz, et al., 2021; Van Loo et al., 2020). However, Van Loo et al. (2020) showed that providing consumers with information on the environmental and animal welfare benefits of meat alternatives could positively affect preferences for plant-based burgers without impacting the demand for conventional meat. Caputo et al. (2023) also observed that the willingness to pay for the plant-based alternative was higher in the informed condition (i.e., consumers knew that the product did not include ingredients of animal origin) than in the blind condition (i.e., no information on product characteristics was provided). Similarly, Banovic et al. (2022a) found a positive effect of information provision on consumers' purchase intention for innovative products with plant-based proteins. Specifically, the authors showed that the effect of information was higher when presented before the first tasting and that the information before the tasting increased the weight of health perceptions over the taste perceptions in explaining participants' purchase intention.

Another crucial aspect influencing the acceptance of food is product familiarity. Consumers are usually more familiar with meat products than they are with their vegetarian counterparts (Boukid, 2021; Caputo et al., 2023; Smetana et al., 2021), and as a consequence, the situational appropriateness differs between the two options (Elzerman et al., 2021). For instance, consumers usually prefer a traditional steak over a vegetarian one when preparing a "special meal" (Elzerman et al., 2021).

Ultimately, the market success of plant-based meat alternatives will vastly rely on understanding consumers' perceptions and beliefs, which are influenced by both nonsensory attributes (e.g., information included on the packaging about the ingredients or products' benefits) and product-specific sensory characteristics (e.g., taste, appearance, texture, smell), which require specific features to avoid negatively impacting plant-based meat products (Banovic & Sveinsdóttir, 2021). Moreover—and in accordance with the second section of this chapter—individual-related factors, such as age, gender, culture, and more specific health and environmental behaviors, are strong determinants in the acceptance of plant-based meat products (Giacalone et al., 2022; Profeta, Baune, Smetana, Broucke, Van Royen, Weiss, Heinz, et al., 2021; Vural et al., 2023).

25.4.2 Consumer perception and sensory evaluation of hybrid meat

Along with plant-based alternatives mimicking foods of animal origins, hybrid meat products—which combine animal and nonanimal ingredients (e.g., hybrid burgers, hybrid meatballs)—are an elegant strategy to ease the transition from a meat-centered diet to more nuanced products that offer environmental and health benefits and a familiar taste (Banovic et al., 2022b; Grasso & Goksen, 2023). Hybrid meat products are foods containing an amount of plant-based ingredients that usually varies between 25% and about 50% (Grasso & Jaworska, 2020).

From 2019, hybrid products have been launched in the European and the U.S. market (e.g., Danish Crowns' 50/50 burgers, Denmark; Applegate's Well-Carved beef/veggie burger, the UK) (Aidan Fortune, 2019; Southey, 2021). It has been estimated that, if 50% of meat is replaced with plant proteins, this novel alternative could promote both human and animal health and reduce greenhouse gas emissions by nearly 32% (Baune et al., 2021). The reported advantages of these products are related to higher sensory acceptance due to their familiar meaty taste (Grasso et al., 2022)—even by consumers who are attached to meat (Banovic et al., 2022a). However, even though hybrid meat is becoming more popular, consumer acceptance is not yet well defined.

The current situation is that many people have values (or abstract, situation-specific aggregated cognitive categories) toward hybrid products as citizens, where they express altruistic, self-transcendent principles, whereas as consumers, they manifest more selfish, self-interest values (Banovic & Barone, 2021). The effect of these on the acceptance of hybrid alternatives depends on the level of self-construal or on how people see themselves in relation to others. Self-transcendent goals (i.e., adopting sustainable behaviors) are dominant in noncommittal interdependent situations (e.g., professing self-environmental identity). On the other hand, self-interest goals (i.e., adopting healthy behaviors) have a stronger effect on the acceptance of hybrid products when it comes to real choices, where independent self-construal is activated (e.g., higher levels of health consciousness). In line with the other plant-based alternatives, environmental concerns are not always the top purchase motive for hybrid products; thus, self-interest goals are usually more influential and health concerns are often prioritized (Asioli et al., 2023). Whether people reveal their self-transcendent or self-interest principles when buying hybrid products is further mediated by the perceived product quality, which has been identified as a decisive factor in the acceptance of hybrid meat (Lang, 2020).

Hybrid meat is often perceived as a plant-based alternative by consumers who are attached to meat (Banovic et al., 2022a; Circus & Robison, 2019). However, the ambiguous nature of these products (part animal, part plant) could also make it difficult for omnivore and flexitarian consumers—who are the main target of hybrid foods—to distinguish between hybrid, animal-based, and plant-based options (Meer et al., 2023). Thus, better market positioning and differentiation strategies should be implemented to ensure that hybrid alternatives could be clearly distinguished at the point of purchase.

In terms of sensory characteristics, research has shown that hybrid meat performs better than plant-based alternatives in terms of both expected and actual taste (Grasso et al., 2022; Neville et al., 2017; Tarrega et al., 2020). Exploring the sensory quality of hybrid meat products with consumers and investigating their motives and barriers are key elements to steer both reformulation and marketing efforts in the right direction. However, studies were primarily carried out in Western countries (e.g., the United States, Denmark, Spain, the United Kingdom, and Germany), and thus, additional research should focus on the sensory analysis and information provision using different meat products in different countries (Grasso & Goksen, 2023).

25.4.3 Consumer perception and sensory evaluation of dairy alternatives

Oppositely to plant-based meat alternatives, plant-based dairy substitutes have been less explored in terms of consumers' acceptance and sensory evaluation. Most of these studies focused on milk and beverage alternatives, whereas research on cheese, yogurt, and other dairy alternatives (e.g., butter) is still scarce (Adamczyk et al., 2022; Yang & Dharmasena, 2020).

Regarding plant-based beverages, curiosity, the need for diversity in the diet, familiarity, health aspects (e.g., different fat contents), and being suitable for lactose-intolerant people are the main motives for consumers to look for these alternatives (Adamczyk et al., 2022). Usually, individuals who are primarily concerned with nutrition, environmental aspects, health, and animal welfare are more likely and more frequently willing to consume plant-based milk substitutes, as well as flexitarians and veg*n(s) (Boaitey & Minegishi, 2020). Conversely, the main barrier to the consumption of these products is their taste, as consumers are seeking plant-based beverages that have similar sensory characteristics to their dairy counterparts. Research on the sensory evaluation of these products strongly confirms that dairy-based beverages are more appreciated by consumers, especially if full-fatted (ca 3% fat), whereas unsweetened plant-based drinks are usually the least preferred (McCarthy et al., 2017). Consumers usually seek products that resemble the animal counterpart—for example, "white appearance" and "milk-like flavor"—and avoid characteristics that are not typical of dairy-based food, such as "grain/wheat flavor" and "cardboard-like" (Cardello et al., 2022; Chung et al., 2022; Collier et al., 2023). Food technologists and developers have also tested several strategies to improve the sensory aspects of plant-based beverages; for instance, blending different types of nuts or adding vanilla or cocoa extracts to the product has shown promising results (Jonas da Rocha Esperança et al., 2022). This methodology can lead to a positive impact on both the taste and the color of the final product (Felberg et al., 2009).

Along with the abovementioned product characteristics, consumers are also influenced by the packaging and the claims displayed on it. For instance, the illustration of the main ingredient (e.g., cashew) can steer consumers' preferences, and claims—especially nutritional and functional ones (e.g., "lactose-free," "cholesterol-free," "prebiotic," "source of protein")—can positively impact individuals' perception and purchase intention of plant-based beverages (Cabral Rebouças et al., 2021; Rebouças et al., 2019).

As for milk alternatives, plant-based cheese substitutes are also facing several challenges in terms of sensory characteristics, especially for their flavor and textural properties. Although some cheese alternatives are appreciated for their softness, buttery taste, and smoothness, consumers—mainly omnivore consumers—express dislike and unhappiness with the sensory attributes of these products (Falkeisen et al., 2022; Pointke et al., 2022). However, given the paucity of literature, more studies should investigate these aspects to better evaluate the sensory profile, consumers' segments, and their acceptance of plant-based cheese (Short et al., 2021).

When it comes to plant-based yogurts, the scientific literature on the topic is significantly smaller compared with the other dairy alternatives. Technological efforts are leading to products with improved sensory characteristics, and the small corpus of research has shown that some of these goods can be considered similar to dairy yogurts in terms of sensory acceptability, especially for their texture (Grasso et al., 2020; Gupta et al., 2022). However, Greis et al. (2023) showed that yogurts with a higher dairy content were more appreciated than samples with lower dairy contents, which indicates that consumers still require improved sensory features that would likely increase the market share of this product category—such as sweet, moist, soft, and smooth (Brückner-Gühmann et al., 2019; Greis et al., 2023; Jaeger et al., 2023). As providing information about the environmental and health benefits of plant-based yogurts did not show impactful results on consumers' acceptability (Jaeger et al., 2023), advancements in food technology and increased awareness of the sustainable and health impact of reducing food of animal origin are needed to allow these products to become mainstream in the global market.

Overall, plant-based milk is by far the most developed and studied category of plant-based dairy products, and it currently accounts for 15% of the total retail milk worldwide (Giacalone et al., 2022). Also considering the other categories (i.e., plant-based cheese and yogurt), the global market and the demand for plant-based dairy alternatives are expected to grow (Wunsch, 2022b), but there are still critical challenges that need to be faced to promote their consumption. First, negative sensory characteristics are a relevant issue as consumers generally prefer the dairy counterpart over the plant-based option (Giacalone et al., 2022; Jonas da Rocha Esperança et al., 2022). Second, most people are not willing to entirely renounce dairy products. Finally, consumers are not fully aware of the environmental benefits related to plant-based dairy substitutes, although they are usually conscious of the health and nutritional benefits of these alternatives (e.g., low-caloric contents and lactose-free features). As suggested by Adamczyk et al. (2022), people rarely associate dairy products with animal suffering and ecological complications linked to industrial farming, and thus, these products do not feel "unpleasant" as meat does.

In order to increase the consumption of plant-based dairy alternatives—and in line with the other plant-based substitutes—there is the need for technological advancements to improve the positive sensory experience related to these products, as well as the promotion of awareness campaigns to educate consumers on the environmental benefits of plant-based products over animal-based dairy (Clune et al., 2017).

25.4.4 Consumer perception and sensory evaluation of egg and seafood alternatives

While plant-based meat and milk alternatives are already consolidated in the global market, egg and seafood analogs represent niche sectors, and studies exploring consumers' perceptions and acceptance of these products are still scarce.

Plant-based eggs are intended to promote environmental sustainability and encourage a reduction in the consumption of animal eggs while addressing food allergy issues (Brennan et al., 2022; Rondoni et al., 2022). One of the first research studies investigating consumers' preferences for plant-based eggs was conducted in 2020. Results showed that people who do not usually consume plant-based food products tend to prefer egg replacements when the product mimics the color and taste of its animal counterpart, whereas vegans and consumers suffering from egg allergies would opt for characteristics that do not necessarily replicate animal eggs (Rondoni, Grebitus, et al., 2021; Rondoni, Millan, et al., 2021).

Overall, a critical factor for consumers is the nutritional content of the plant-based product. The reason for this tendency is to be traced to the general understanding that traditional eggs are known for being an optimal source of proteins, vitamins, and omega 3, and thus, people would expect a similar nutritional profile in egg analogs (Rondoni, Grebitus, et al., 2021; Rondoni, Millan, et al., 2021).

Another relevant aspect for consumers is the packaging and the claims displayed on it. Consumers believe that manufacturers should use the packaging to convey important messages, such as a "clean" ingredient label (e.g., short ingredient list), health benefits (e.g., allergen- and cholesterol-free), animal welfare (e.g., does not involve animals), safety aspects (e.g., it is free from contaminations such as salmonella, antibiotics), and sustainability elements (Rondoni, Grebitus, et al., 2021; Rondoni, Millan, et al., 2021).

Consumer studies on plant-based eggs are still in their infancy, and results cannot be generalized to a wide population, as research was carried out in just a few countries (Italy and the United Kingdom) (Rondoni, Grebitus, et al., 2021; Rondoni, Millan, et al., 2021). Further research is needed to investigate not only preferences and attitudes toward this product category but also sensory expectations and perceptions, which have not been explored so far.

Despite consumers' perspectives on plant-based egg alternatives being little investigated, aspects covering seafood alternatives have been even less explored. In 2022, a study by Boukid et al. assessed the nutritional profile of seafood analogs (e.g., tuna, calamari, fish fillets, and fish fingers) compared with conventional products. The research showed that plant-based seafood alternatives have variable nutrient contents, and in many cases, they substantially differ from the nutritional profile of their animal counterpart (Boukid et al., 2022). However, the study did not analyze consumers' perception of these nutritional differences, and in terms of consumer science, it is quite laborious to find scientific articles investigating consumers' behavior, attitude, and sensory expectation for this food category. The dearth of research on this topic concurs that consumers' interest in these products is still low, and they are not ready to add them to their regular diets (Estell et al., 2021; Gorman et al., 2023). Although messaging about the benefits of seafood substitutes and viewing the ingredient list could increase the willingness to try and to pay for the product (Gorman et al., 2023; Kim et al., 2023), the key factor for driving consumers' perception is the successful replication of complex sensory aspects (Gorman et al., 2023). As a matter of fact, despite being aware of the environmental benefits of plant-based fish alternatives (but less conscious of their healthiness), consumers are mostly hindered by the taste and texture seafood analogs could have (Gorman et al., 2023). Further research should expand on this topic to investigate attitudes and motives toward the consumption of seafood alternatives. Additionally, sensory evaluation is required to explore whether exposure to these products could impact consumers' perceptions.

The lack of scientific evidence for egg and seafood analogs is probably because these are still niche market sectors. Technological innovations for these product categories have recently accelerated, and their market share is expected to increase in the near future. Therefore, it is not possible—as of the writing of this chapter—to provide a comprehensive overview of consumer perceptions and sensory evaluation of plant-based egg and seafood alternatives. Ample room exists for future studies to cover innovative aspects that could be of benefit to manufacturers, health professionals, and policymakers.

25.5 Discussion and conclusions

The growing demand for plant-based foods as an alternative to animal-sourced proteins is expected to rise in the upcoming years (Andreani et al., 2023; Aschemann-Witzel et al., 2020). Given this prediction, policy and marketing

strategies are needed to ensure that nonanimal products are more accessible to omnivore consumers who might not be willing to entirely eliminate certain foods from their diets (i.e., becoming veg*n) (Banovic et al., 2022a). One strategy to promote this transition is to produce plant-based alternatives that resemble their animal counterpart without compromising sensory characteristics, as many consumers still desire the specific flavor, texture, mouthfeel, and feeling of various animal-derived products (FAO, 2022). The plant-based analogs market is a vibrant sector, which merits further exploration and assessment, as emphasized by the significant growth figures it is experiencing and will likely continue undergoing in the near future. The increasing availability of these products in supermarkets and food chains (including McDonald's, Burger King, and KFC having released plant-based versions of beef burgers and chicken nuggets), the substantial investments of the latest decades, and the remarkable efforts to improve the product qualities, all testify the influence this sector has gained for both consumers and manufacturers.

Another strategy would be to go beyond the product purchase and tackle the moment of the pre- and postconsumption to provide consumers with information, ideas, and recipes on how to use and cook new meals that can solidify the footing of plant-based products in the market (Banovic et al., 2022a). This is one of the key gaps that most companies are not considering in today's marketplace.

However, to support this sector and promote a transition toward healthier and more sustainable eating behaviors, it is critical to assess and understand consumers' perceptions and beliefs. The fact that people express their concerns about diet, climate change, and various aspects of meat production when prompted to share their opinion is often inconsistent with their actual behavior (De Barcellos et al., 2011; ElHaffar et al., 2020). Despite the ample evidence on people's health concerns related to meat consumption (Barone et al., 2021; Macdiarmid et al., 2021), eating habits do not seem to be healthier (Eurostat, 2023). Similarly, regardless of the increased awareness of environmental issues (Circus & Robison, 2019; Pais et al., 2020), consumers' actions do not always or automatically become more sustainable (FAO, 2022). Nevertheless, changes are possible, and hybrid and plant-based options have the potential to facilitate the shift from meat-centric dishes to plant-forward dishes (Banovic et al., 2022b), thus promoting the reduction of foods of animal origin without requiring a strict shift to veg*sm (Spencer & Guinard, 2018; Spencer et al., 2021).

One relevant aspect to take into consideration when referring to consumers' views and beliefs is that drivers to reduce the consumption of meat, and foods of animal origin are likely to vary between countries (Adamczyk et al., 2022; Bryant et al., 2019). Given the global perspective of this chapter, this hypothesis is particularly relevant. At present, comparative research on consumer motives in favor of limiting the consumption of foods of animal origin that highlights country-specific traditions and circumstances represents a knowledge gap (Bakr et al., 2022; Bryant et al., 2019; Greis et al., 2023). Future research may be conducted to gain insight into how and to what extent culinary habits, social surroundings, and (un)availability of affordable and palatable plant-based alternatives are country-specific (de) motivators of consumer acceptance.

Regardless of the type of plant-based alternative, common aspects related to consumers' responses can be identified. First, information provision often increases the interest and the attitude toward these products, and thus, communication campaigns and the use of labels (e.g., the Nutriscore and the Ecoscore) should be considered to allow consumers to make informed choices and provide them with the necessary tools to understand the health and the environmental impact of foods (Grasso et al., 2022; Martin et al., 2021; Smetana et al., 2021; Van Loo et al., 2020). Second, along with high prices, the relatively low familiarity/availability of these products is a critical aspect associated with consumers' preferences. To allow plant-based alternatives to become mainstream in the market, it is necessary to foster familiarity—for instance, through free tasting sessions in supermarkets. It has also been recommended to increase the availability of plant-based analogs in school canteens to familiarize younger generations with these alternatives (Profeta, Baune, Smetana, Broucke, Van Royen, Weiss, Heinz, et al., 2021; Sogari et al., 2022). Last, even if familiarity and information about the benefits could support consumers in their choices, the sensory appeal remains a critical factor for acceptance (Caputo et al., 2023; Fiorentini et al., 2020). Limited animal-like sensory features—either expected or experienced—represent a strong barrier to replacing traditional animal products with plant-based alternatives. To further investigate this issue, studies on consumers' perceptions of plant-based substitutes should include more direct experience with such products as well as consider different contexts and purchasing situations (Elzerman et al., 2021; Sogari et al., 2022). To become successful among consumers and avoid market failure, a consumer-oriented approach to product development is required—for instance, by codesigning products with consumers or by integrating both sensory and consumer sciences. As a matter of fact, an increasing body of literature on sensory studies stresses the importance of employing untrained panels to evaluate product characterization and provide actionable insights on product development and marketing of novel foods (Grasso et al., 2022; Smetana et al., 2021). This collaboration with consumers (i.e., product cocreation) could provide actionable directions not only to optimize sensory attributes during product development but also to improve overall consumer acceptance in terms of situational and cultural appropriateness (Barone et al., 2021; Sogari et al., 2022).

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