8. MEAT ALTERNATIVES—MARKET AND CONSUMPTION

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Abstract

Elimination of animal-based products, often related to a vegetarian or vegan diet, is one of the most popular nutritional trends observed around the world. This chapter provides an overview of the assortment, market and consumption of various meat alternatives. Products replacing meat are made of various types of (mostly) plant-based raw materials including pulses/legumes, cereal proteins (mainly gluten), oilseeds, fungi (edible mushrooms) and algae; however, cultured meat and edible insects are also described. The market of meat alternatives was estimated at USD 10,11 billion in 2022 and is expected to grow at a compound annual growth rate (CAGR) of minimum 15% by 2030. Europe has the largest share (52%) of the global market followed by North America (27%), Asia Pacific (12%), Latin America (6%) and Middle East and Africa (4%). The top producers are Beyond Meat, Boulder Brands, Hain Celestia, Nestlé, Garden Protein International, Vivera, Lightlife Foods, Woolworths, Naturli' Foods and Sainsbury's. Despite the fact that vegetarians and vegans constitute 6.4% and 6% of global consumers, respectively, more and more people are willing to either reduce the consumption of meat (62%) or animal-origin (42%) products. This is due to the fact that the consumption of meat-free products plays a role in sustainable development considering multiple health, economic and environmental issues.

Keywords: diet quality, environmental impact, meat alternative, meat-free, sociocultural acceptability, sustainable nutrition, vegan, vegetarian.

JEL codes: D12, D13, I11, I12, I15.

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Introduction

Elimination of animal-based products, generally called a vegetarian or vegan diet, is one of the most popular nutritional trends observed around the world, which results also from the obligation to follow a vegetarian diet in individual religious sections (Ahmad et al., 2022). Consumption of meat-free products also plays a role in sustainable development considering multiple health, economic and environmental issues. Therefore, this chapter provides an overview of the global market of meat-free products. It also describes the popularity and consumption of selected meat, dairy and egg alternatives.

Meat is an important source of protein, which delivers all essential amino acids necessary for human health. It is also highly valued by many consumers due to favourable sensory properties such as texture and flavour (Zahari et al., 2022). However, meat consumption has raised various ethical, health and environmental concerns. Therefore, over the past years, consumers have shifted their eating patterns, seeking dietary alternatives (Starowicz et al., 2022). Meat alternatives refer to meat-free products that try to mimic traditional meat. Meat alternatives are (mostly) plant-based, high-protein products that can replace food of animal origin (Czerwinska, 2020). However, cultured meat and edible insects should also be considered as meat alternatives. All these types of products are called meat alternatives, as well as meat analogues, meat substitutes, mimic meat, mock meat, vegetarian meat, plant-based meat, synthetic meat, amalgam meat or health-promoting meat (Ahmad et al., 2022; Vallikkadan et al., 2023), and are described in paragraph "Assortment of meat alternatives".

Based on plant raw materials, high-protein products are foods with a positive, targeted effect on the human body. The growing awareness of consumers regarding the way of eating in order to maintain health and good condition increases interest in protein sources alternative to animal products (Hoffmann & Jędrzejczyk, 2010). There are many health benefits associated with eating meat analogues. Reduced consumption of animal meat can help primarily in lowering cholesterol levels as well as reduce the risk of developing cardiovascular diseases such as heart attack or stroke. In contrast, daily consumption of animal meat increases the risk of developing colorectal cancer (Hu et al., 2019). A particularly high health risk is associated with the consumption of red meat and processed meat in the amount exceeding 500 g per week (Herforth et al., 2019).

Meat alternatives, in addition to supporting people's health and well-being, also help to mitigate the negative impact of production and consumption of animal meat on the environment. Undeniably, meat production burdens the environment. It consumes a large amount of the earth's resources and drinking water. It causes environmental pollution, greenhouse gas emissions, loss of terrestrial and aquatic biodiversity, and increases the risk of animal diseases (Van der Weele et al., 2019).

According to Ahmad et al. (2022), currently about 30% of global warming and climate change has its source in the food industry. Global animal production requires about 2,400 Gm^3 of water per year, and as much as 70% of global freshwater is used for agriculture. For example, the average water footprint per calorie of beef is twenty times higher than that of cereals and root crops (Mekonnen & Hoekstra, 2010). In addition, meat production contributes to eutrophication, i.e. pollution of water and ecosystems with excessive content of nutrients, which is a serious environmental problem. According to a report presented in 2018, producing one kilogram of beef contributes to the emission of 365 g of phosphate equivalent (PO_4eq) (Poore & Nemecek, 2018). Despite the fact that phosphates are not harmful to humans, their presence in water disturbs the balance of aquatic organisms, causing algal blooms, which can already have a direct (negative) impact on the health of people living in nearby areas (Kleinman et al., 2011). Moreover, another research shows that people who follow meat-free diets have a real influence on reducing the negative impact on the environment. A study from 2017 comparing the impact of different diets, both meat and meat-free on the environment, took into account three indices considered to be the most representative for the agri-food system, i.e. carbon footprint—expressed as gCO_2 eq/kg, including greenhouse gas emissions, water footprint—expressed in L/kg of water resources consumption and ecological footprint—expressed as global m^2/day of biologically productive land/sea needed to produce a food product unit (Rosi et al., 2017). An analysis of the environmental impact of these three types of diet showed that the animal-based diet had a significantly greater impact on each of the environmental indicators compared to the others. For example, the average CO_2 emission for a traditional (meat) diet, expressed as an average of 7 days, was about 3960 gCO_2 eq/kg, while the average for a vegan diet was about 2340 gCO_2 eq/kg. Similar disproportions were also shown for the ecological footprint. On average, about 26 m^2 of land/water resources per day were used for the production of traditional (meat) diet ingredients, while in the case of vegan products, it was about 14.5 m^2.

Therefore, consumers' awareness of health, environmental sustainability and animal welfare has shifted people's attention from the meat of animal origin to the meat of plant origin and the scale of this trend (market and consumption) is described in the following sections.

8.1. Assortment of meat alternatives

The market of meat substitutes is mostly associated with vegetable-based products. However, cultured meat and edible insects should also be considered as potential meat alternatives. Plant-based meat analogues can replace traditional meat, being a nutritionally sustainable source of protein (Choudhury et al., 2020). Meat

substitutes as alternative sources of animal protein, based on plant raw materials, are produced using various plant proteins, such as oilseed proteins, cereal proteins, legume proteins and leaf proteins. Oilseed proteins are obtained from soybean, canola, sunflower weed, sesame, chia seeds, pumpkin, grape seeds, linseed, and cereal proteins are obtained from wheat, corn, rice, barley, sorghum and amaranth (Czerwinska, 2020; Kurek et al., 2022; S. Y. Lee et al., 2023).

Animal protein substitutes can be traditional protein foods of plant origin, which are used as a substitute for meat protein, for example, tofu or seitan (Vallikkadan et al., 2023). Substitutes can also be foods that are not only a source of protein but are also consciously designed so that their taste and structural properties imitate meat through the use of plant ingredients, called plant-based meat analogues (PBMA) (Huang et al., 2022; S. Y. Lee et al., 2023). Vallikkadan et al. (2023) referred to these substitutes as meat fillers and meat analogues. Meat fillers are products that are used to replace fresh meat of animal origin. Meat analogues, on the other hand, are foodstuffs that mimic meat of animal origin. Such products are similar in appearance and structure to muscle meat (Vallikkadan et al., 2023). Their texture, colour, flavour and aroma may reflect specific types of meat (Ahmad et al., 2022). Such meat substitutes may also offer a similar nutritional composition as traditional meat, but with many additional ingredients and a high level of processing (Bohrer, 2019).

Table 8.1 shows products that can replace meat of animal origin, made of various types of raw materials: pulses/legumes, cereal proteins (mainly gluten), oilseeds, fungi (edible mushrooms), algae, cultured meat or edible insects.

Table 8.1. Most popular plant-based meat alternatives

Meat alternatives sourced from pulses/legumes	
Tofu	Made from soybeans, also referred to as soya curd. Made by curdling fresh hot soy milk with a coagulant. It comes in the form of blocks and contains high amounts of protein, calcium and iron (Obatolu, 2008). Tofu is widely used around the world as an alternative to meat in the food industry (Singh et al., 2021)
Tempeh	It is made by fermenting soybeans. It is a product with a hard texture and consistency similar to a rubber mushroom (chewy mushroom). It is rich in protein and fibre and contains vitamin B-12, which is a by-product of the fermentation process (Babu et al., 2009)
Yuba	Yuba is a protein-fat skin that forms on soy milk and has a characteristic slightly rubbery texture. It is mainly used to produce meat analogues or as an addition to soups and desserts. When fried, it forms a layer imitating roasted chicken skin (Hoffmann et al., 2009; Singh et al., 2021)
Kinema	A soybean fermented alkaline meat substitute (Sarkar et al., 1994)
Soy concentrates	Soy protein concentrate contains about 70% protein. Used as an additive to meat substitutes. Mainly used for making such products as: sausage, luncheon meat, pâté or burger (Hoffmann et al., 2009)
Soy isolates	The most concentrated source of protein, min. 90%. In vegetarian products, they are used as an enriching substance for the production of meat analogues (Hoffmann et al., 2009)

Table 8.1 – cont.

Soy protein textures	TVP (Textured Vegetable Protein) is obtained in the extrusion process from flour, concentrate or soybean isolate. It contains from 50% (flour textures) to 65%–70% protein (concentrate textures), with a fat content of less than 1% and no more than 3.5% fibre (Hoffmann et al., 2009)
Meat alternatives sourced from cereals	
Seitan	Called wheat meat in vegetarian cuisine because the main ingredient is wheat flour. Seitan has a texture very similar to meat. It is a source of protein, iron, B vitamins and small amounts of fat (Hoffmann & Jędrzejczyk, 2010; Singh et al., 2021)
Wheatpro	A product derived from wheat gluten, transformed and extruded to give it a meat texture. It is available on the market in the form of flakes, ground or chopped (Singh et al., 2021)
Arrum	It is a converted mixture of gluten and pea proteins in a 1:1 ratio. The finished product resembles pieces of meat in appearance and structure. It is used to produce, for example, lasagne or dumplings (Hoffmann & Jędrzejczyk, 2010)
Trivall	It is obtained from wheat gluten and vegetables protein. Available in frozen form, ready to eat after heating, in the form of analogues of burgers, sausages, nuggets or schnitzels (Hoffmann & Jędrzejczyk, 2010)
Meatless	Vegetable fibres obtained from sweet lupine seeds, seaweed and wheat. Meatless is a semi-finished product with a texture typical of meat (Hoffmann & Jędrzejczyk, 2010; Singh et al., 2021)
Meat alternatives sourced from fungi (edible mushrooms)	
Quorn	Meat substitute, the main ingredient of which are mycoproteins derived from the mold strain *Fusarium venenatum*, which occurs naturally in the soil. The obtained mycoproteins are purified, dried and mixed with egg white (in the vegan version, potato protein is used as a binder). The product is sold in many countries around the world both as a semi-finished product for further processing and in the form of ready meals (chops, sausages) (Jurek, 2019)
Meat alternatives sourced from oilseeds	
Fibres	Product obtained from sweet lupine seeds after mixing with wheat flour (Singh et al., 2021)
Meat alternatives sourced from microalgae	
Remis algen	An algae-based product. Algae mixed with other potential plant proteins such as cereals, rice or cooking oils (Singh et al., 2021)
Meat alternatives sourced from cultured meat	
In-vitro meat	Also called lab-grown meat; it is artificial meat produced using stem cell technology. Comes from farm animals, so it is very similar to regular meat (H. J. Lee et al., 2020; Van der Weele et al., 2019)
Genetically Modified Organisms (GMO)	Meat of genetically modified animals (H. J. Lee et al., 2020)
Meat alternatives sourced from edible insects	
Extracted protein from insects	Insects used as food resources. A valuable source of protein due to their high protein content with essential amino acids sufficient to meet our daily needs (H. J. Lee et al., 2020)
Whole insects	Low acceptance of insect eating among Western consumers. In Africa, South America and Southeast Asia eating insects is an ancient custom (H. J. Lee et al., 2020; Van der Weele et al., 2019)

Source: own elaboration.

8.2. Market of meat alternatives

There are many manufacturers of meat substitutes operating at the national (Polish) and international market. Research conducted in 2022 among Poles indicated the Tarczyński brand as a top brand of plant-based meat alternatives. Almost half of the respondents (45%) declared that they add meatless products of this manufacturer to their shopping list. The respondents also chose the GoVege (21%) and Vemondo (14%) brands (Table 8.2) (Statista, 2022). The world's most popular plant-based meat analogue brands are also listed in Table 8.2.

Table 8.2. Most popular plant-based meat alternatives brands in Poland and around the world

POLAND		WORLD
Brand	**Share of users (%)**	**Brand (alphabetical order)**
Tarczyński	44.7	Beyond Meat
GoVege	21.1	Boulder Brands
Vemondo	13.7	Hain Celestia
Dobra Kaloria	6	Nestle
Garden Gourmet	5.2	Garden Protein International
Olewnik	2.2	Vivera
Ona Day More	2	Lightlife Foods
Z Gruntu Dobre	1.5	Woolworths
Well Well	0.8	Naturli' Foods
BezMięsny	0.7	Sainsbury's
Other	2.2	

Source: based on (Boukid, 2021; Statista, 2022).

The market of meat alternatives continues to grow due to the increasing demand for plant-based products visible around the world (Singh et al., 2021). Throughout the world, it has recorded systematic increases in recent years. The value of vegetable meat sales around the world in 2022 was estimated at USD 10,11 billion (Statista, 2023b). Forecasts indicate that this number will continue to grow over the next few years and will reach approximately USD 33,99 billion in 2027 (Figure 8.1) (Statista, 2023b).

The size of the global market for meat alternatives is expected to grow at a compound annual growth rate (CAGR) of 42.1% between 2022 and 2030 (Grand View Research, 2022). Some sources forecast that the global meat substitute market will reach USD 30.92 billion by 2026, with a compound annual growth rate (CAGR) of 14.8% (Singh et al., 2021). The Union Bank of Switzerland (UBS) predicts that the global plant-based meat market will reach $51 billion by 2025 (UBS, 2021). Europe has the largest share in the global market of meat analogue products (51.5%), followed by North America (26.8%), Asia-Pacific (11.8%), Latin America (6.3%)

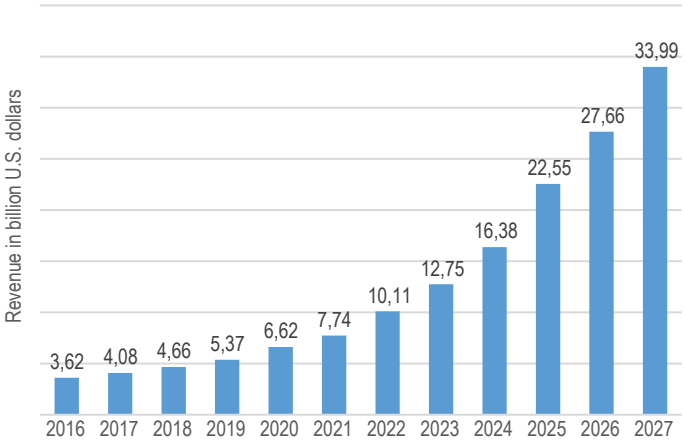

Figure 8.1. Market revenue of plant-based meat worldwide from 2016 to 2027
Source: (Statista, 2023b).

and the Middle East and Africa (3.6%) (Boukid, 2021). Data from 2021 indicate that the country with the largest revenues from the meat substitute market will be China, generating approximately USD 2,1 billion. The US comes in second with USD 1,5 billion, followed by the UK with USD 847 million in revenue. Russia and Germany will also generate high revenues (Statista, 2021d).

In 2020, the North American continent had the largest share of the global plant-based meat market (44%). Western Europe also had a large market share of plant-based alternatives (34%). The Middle East and Africa had a market share of around four percent, Latin America around 3%, and Eastern Europe and Australasia around 2% (Statista, 2021c). In Europe, the leading market for meat alternatives was the UK, with sales more than EUR 502 million. The size of the German market was approximately EUR 357 million and the Dutch market was approximately EUR 174 million. By comparison, sales of meat substitutes in Romania only reached around EUR 5 million in 2020 (Statista, 2020).

In 2015, over 6,485 new plant-based meat analogues appeared on the global market (Huang et al., 2022). A report published by the Good Food Institute indicates that in 2019, the best-selling categories of plant-based meat substitutes were burgers, with sales of USD 283 million, links (sausages and hot dogs) (USD 159 million) and patties (USD 120 million) (GFI, 2021). The market for meat and meat substitutes is expected to change in the coming years 2025–2040. Today, the market is dominated by traditional meat products. This dominance is expected to continue until 2025. However, in the coming years, this trend will decrease, and in 2040, these products will constitute a minority of available products. In 2040, the market is expected to consist of about 40% of traditional meat products, about

35% of farmed meat or lab-grown meat products, and about 25% of vegan meat alternatives (Figure 8.2) (Statista, 2021a).

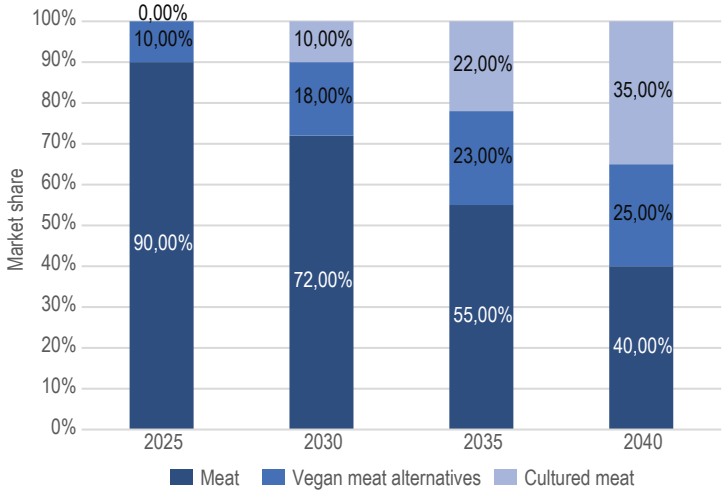

Figure 8.2. Composition of the meat and meat alternatives market worldwide from 2025 to 2040
Source: based on (Statista, 2021a).

8.3. Consumption of meat alternatives

People are increasingly switching to a plant-based diet out of concern for the treatment of animals, the environment or for their own health. Popular plant-based diets include a vegetarian diet—a diet excluding meat and fish, the pescatarian diet—which is largely vegetarian but also includes seafood, and a vegan diet—a type of vegetarian diet that excludes meat, fish and all products of animal origin, such as milk or eggs (Shmerling, 2019).

A meat-free diet is a diet that focuses on plant-based proteins, such as beans, lentils, nuts and soybeans, and may also include dairy and eggs (Lachtrupp, 2021). The term plant-based diet is defined by Hargreaves et al. (2023) as "an eating pattern in which foods of animal origin are completely or mostly excluded". Plant-based diets have a number of advantages. They contain large amounts of nutrients, vitamins, micronutrients and macronutrients (Singh et al., 2021). Many years of research have shown that plant-based diets are associated with a lower risk of cardiovascular disease, heart disease, obesity, type 2 diabetes and some cancers (compared to diets rich in meat and other animal products) (Kalchenko, 2016). A balanced and varied meat-free diet is suitable for people in all phases of life (Kalchenko, 2016).

Currently, animal meat alternatives are not only consumed by vegans and vegetarians. They are also becoming popular with the wider carnivorous population. According to a recent Nielsen market report, 62% of respondents are willing to reduce meat consumption and 43% would like to replace meat proteins with plant-based products (Huang et al., 2022). A study conducted in 2020 indicated that vegetarians and vegans constitute a small group of global consumers, with vegans amounting to 4% and vegetarians to 6.4%. A larger group of global consumers are people who do not follow a strict meat-free diet but try to limit products of animal origin—they constitute 42% of consumers worldwide (Passport, 2020). In 2021, a survey was conducted in various European countries where respondents answered the question "Do you avoid eating meat?" (Figure 8.3). The study shows that the largest percentage of non-meat eaters in Europe live in Ireland and the British Isles, around 15% of the population. For comparison, consumers living in the Czech Republic and Hungary have the lowest share; they limit meat in negligible amounts, only 5% of the population (Statista, 2021b). In Poland, in 2023, only 8% of respondents declared that they only eat meat alternatives, while 34% admitted that they eat both meat and its alternatives (Statista, 2023a).

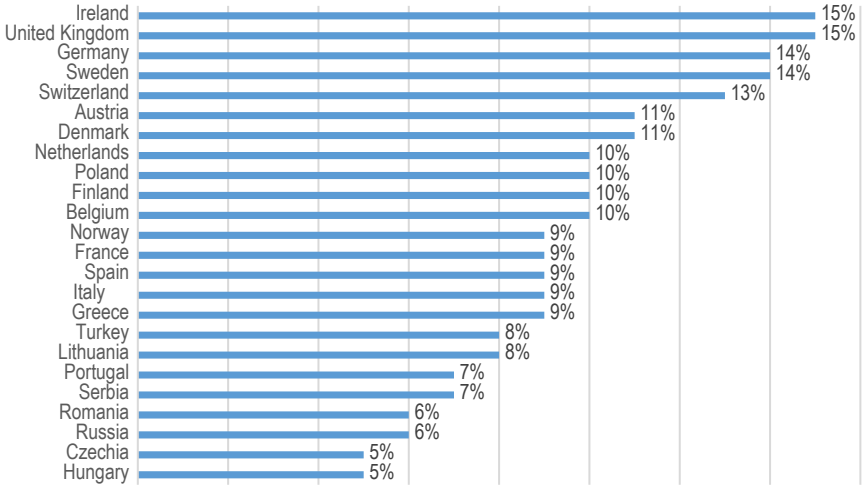

Figure 8.3. Share of vegetarians, vegans and pescatarians in selected European countries in 2021
Source: (Statista, 2021b).

Figure 8.4 shows the share of vegetarians and vegans in selected countries worldwide in 2021 and 2022, respectively. India is the leading country when it comes to the share of vegetarians amongst its population. Almost a quarter of the respondents from India were following a vegetarian diet according to a survey carried out in 2021. Vegetarianism in the United States, by comparison, amounted

only to a share of five percent of the respondents. In 2022, around three percent of responding German consumers between 18 and 64 years of age followed a vegan diet. In Brazil, China, Mexico and the U.S. between two and six percent of the respondents are vegan. The noteworthy standout is India where over a tenth of respondents said they typically follow a vegan diet. The survey was carried out among online users.

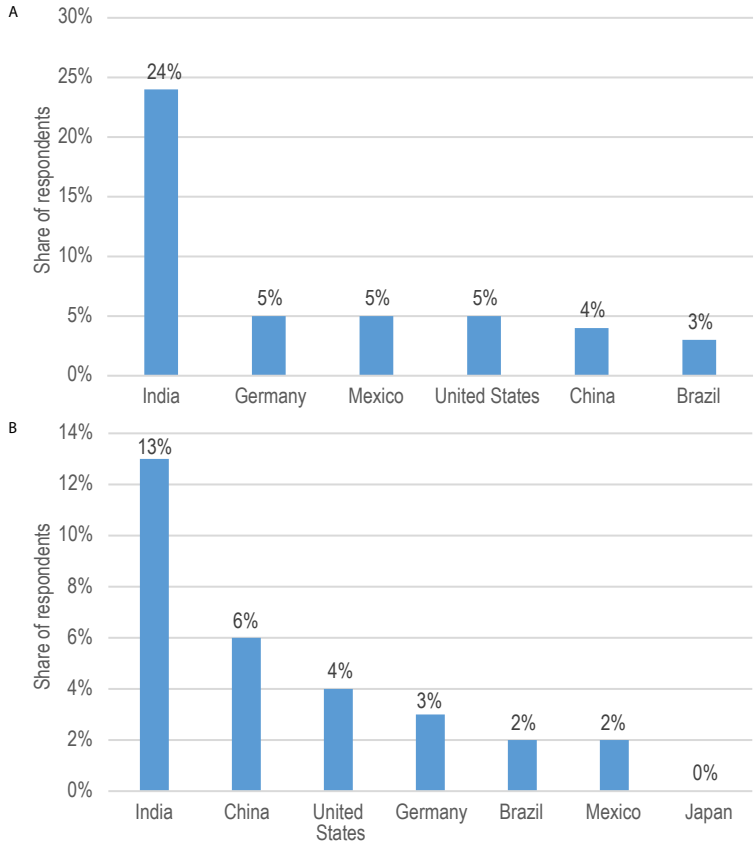

Figure 8.4. Share of vegetarians (A) and vegans (B) in selected countries around the world in 2021 (A) and 2022 (B)

Source: (Statista, 2023c, 2023d).

Conclusions

The chapter provides an overview of the global market of meat-free products and the popularity of meat, dairy and egg alternatives. It discusses the reasons behind the shift towards vegetarian and vegan diets, including ethical, health

and environmental concerns. The market for meat alternatives is predominantly plant-based, but it also includes cultured meat and edible insects. Various types of plant-based proteins are used in meat substitutes, such as oilseed proteins, cereal proteins, legume proteins and leaf proteins. The chapter highlights popular brands of meat alternatives and the growth of the market, with estimated revenues reaching USD 40 billion in 2027. Consumer consumption patterns are shifting towards plant-based diets, with an increasing number of people reducing their meat intake or opting for plant-based protein sources. The trend is not limited to vegans and vegetarians, as even carnivorous consumers are embracing meat alternatives these days.

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