

Review Article

Development of Plant Meat and Factors Affecting Its Acceptance: Perspective of China

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Abstract

People's quality of life has been significantly improved, and green health is the future dietary theme. Plant-based meat alternatives have become a hot topic and research object in various countries. This paper aims to review the development process of plant meat, summarize the development and promotion policies of plant meat in China, and study the factors that affect consumers' acceptance of plant meat in China. China has a deep historical relationship with plant meat, but now the development of plant meat in China is only in its infancy. Many national policies in China are in line with the concept of plant meat, such as the Peak Carbon Dioxide Emissions, Carbon Neutrality, and the Greater Food, which are promoting plant meat to enter the China market. Taste, flavor, and price are significant factors that restrict consumers' purchases, and the intervention of social policies and the influence of religion will also enhance consumers' acceptance. Finally, this paper puts forward some policy and enterprise suggestions for the future development of China's plant meat market.

Keywords: Consumer acceptance; Development course; Influencing factor; Plant-based meat alternatives

Introduction

Since antiquity, meat has been considered a vital component of human diets [1,2]. Notably, the recent decades have witnessed a 58% surge in global meat consumption due to increased population [3]. The latest agricultural outlook issued by the OECD-FAO predicts the demand for meat to reach an astounding 374 million tons by 2030 [4].

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This burgeoning appetite has caused several predicaments, such as zoonotic diseases [5], cardiovascular illnesses [6], and cancers, particularly colorectal [7,8], and animal welfare [9-12]. But the social requirements of green economy and circular economy and people's health have changed the future dietary structure [13].

In response to these concerns, the food industry is actively seeking to develop meat alternatives. Plant-based meat alternatives are fabricated from bean products, such as grains, beans, and peanuts, mimicking the texture, taste, and appearance of meat products [10,14]. The fibrous and anisotropic structures of these plant-based alternatives contribute to their ability to replicate the surface and sensory qualities of real meat crucial to consumer acceptance [9]. The market for plant-based meat has rapidly expanded due to its alignment with health, eco-friendliness, morality, sustainable development, and ethics [11,15,16]. Scholars hold differing opinions on concerns such as technical challenges in production and the health benefits of plant-based meat [17]. Views range from criticism that it is not real food [18] and may even be hazardous [19], to seeing it as an environmentally-friendly food and an inevitable trend in the global market [20]. Various research articles approach plant-based meat from multiple perspectives. Dekkers, Boom [21] et al. and Kumar [22] detailed critical technological advancements in the manufacturing process, with an emphasis on structure. Raychel E. Santo et al. [23] reviewed the significant impacts on public health, the environment, animal welfare, economics, and policy associated with plant-based and cellular meat alternatives, comparing them to those of farmed meat. Paula Albuquerque Penna Franca [16] differentiated the technical and nutritional aspects between the first and second generations of meat alternatives available in the Brazilian market. Meanwhile, Hu, Otis, and McCarthy conducted a life-cycle assessment to evaluate the environmental sustainability of plant-based meat products. Zhong Chengxuan et al [15] summarized the latest production technology for plant-based fish analogs, highlighting the challenges and opportunities for commercialization.

Undoubtedly, plant-based meat has rapidly gained a substantial market share worldwide. According to Bloomberg Information, the global market for plant-based foods is projected to quintuple between 2020 and 2030, as depicted in Figure 1. Previous studies have yet to provide a comprehensive understanding of the historical evolution of plant-based meat products and driving forces behind their growth in China. This study aims to examine the developmental trajectory of plant-based meat, identify factors that facilitate its growth, investigate the key determinants that affect Chinese consumers' acceptance of plant-based meat, and ultimately, present this paper's holistic conclusions.

The Development of Plant Meat

A comprehensive analysis of plant-based meat development is imperative and can offer insight into future growth and demand based on the developmental trajectory of plant-based meat. This study will delineate the various stages of plant-based meat development and their implementation in China. The fundamental progression of plant-based meat is presented in Figure 2 below.

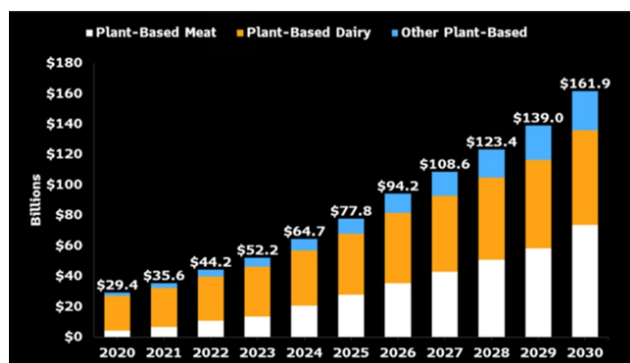


Figure 1: Global Plant-based Food Market Growth Chart.

Source: Bloomberg Information

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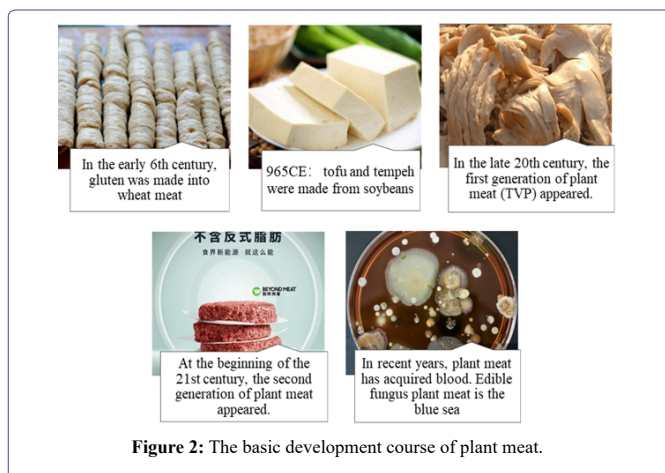


Figure 2: The basic development course of plant meat.

Initial development of plant meat

The concept of meat alternatives in cuisine is not novel, and the origins of plant-based proteins can be traced back to ancient China and India [24]. Most ancient Chinese vegetarians were devout individuals who adhered to religious principles, such as Buddhist precepts spreading non-violence and cherishing life, Taoist values of self-restraint, and Confucian moral principles of benevolence [25]. Even in the Song Dynasty period (BC960-1279) plant-based meat derived from soy products, such as vegetarian chicken, fish, pork chops, and balls, had gained significant popularity in society [26]. Similarly, Buddhism held a significant influence in ancient India, where various religious beliefs contributed to a prevalence of vegetarianism [2]. Plant-based proteins such as tempeh in Indonesia, tofu in India, and wheat gluten (Seitan) as a pure meat substitute, have been utilized extensively. With a texture similar to that of meat, gluten - one of the primary protein components of wheat - was processed to obtain a sticky insoluble gluten that resembled meat. This wheat meat has been used in traditional dishes dating back to the early 6th century [27]. Notably, meat alternatives were popularized in several Southeast Asian countries as traditional cuisine, as early as AD 965 [28].

First-generation plant meat

In the middle to late 20th century, Taranto demonstrated that soy protein isolate mixtures could be used to produce artificial meat and organized plant proteins. Extrusion screws were used to produce

meat-like products from soybeans and glandless cottonseed meal [29]. The emergence of Tissue Plant Protein (TVP), also known as the first generation of meat alternatives, provided elastic and spongy textures similar to meat [14,30]. TVP is typically made from soybeans, such as Textured Soybean Protein (TSP), which contains high-quality protein for use in meat alternatives [28].

Different from the above two other plant meat products, the UK's plant meat product employs *Fusarium* fermentation technology to produce mold protein with natural ingredients, low fat and high protein. This raw material can be used to prepare high-quality plant meat products like sausages and hamburger meat slices through different processing methods [31]. Although initially catering to vegetarians, the product faces a limited market [32]. In the early 21st century, consumers valued healthy living and food choices. While meat demand remained high, meat alternatives gained popularity. Plant-based meat gradually became the mainstay of a healthy diet. Plant meat gradually became the mainstream of a healthy diet [33]. Soybean protein was the dominant plant alternative to meat, along with glandless cottonseed meal, rapeseed, rapeseed concentrate and defatted peanut powder [34]. These ingredients were used to produce a wide range of products including hot dogs, bacon, luncheon meat, ground beef, and hamburger patties, all based on TVP [35].

Second-generation plant meat

The first generation of plant-based meat was initially popular among vegetarians and some consumers desiring a healthy diet. However, its appearance, flavor, and taste were unsatisfied [24], thus highlighting the need for second-generation plant meat development. In the early 21st century, advancements in plant-based meat production technology led to the introduction of the second-generation plant meat products. TVP continued to be the core technology for achieving a meat-like texture. The second generation of plant-based meat exhibited improved appearance, nutritional content, nutrients, and aroma, more closely resembling authentic meat products compared to its predecessor [35]. Furthermore, several Western companies, including Beyond Meat, Impossible Foods, and Light Life, have effectively introduced plant-based meat to the market. These companies have developed soybean hemoglobin as a means of creating a red color resembling meat blood, thus addressing iron deficiencies inherent in plant-based meat products. Beyond meat is prepared with non-transgenic components such as beetroot, which also endows plant meat with blood [30]. The Beyond Meat IPO was a success and paved the way for collaborations between plant-based meat companies and fast-food restaurant chains worldwide. Examples of such collaborations include Impossible Foods partnering with Burger King to launch the Plant Meat Burger, and Kentucky Fried Chicken offering boneless chicken wings and nuggets developed with Beyond Meat and Light Life. This collaboration has sparked a wave of similar partnerships in the plant-based meat industry [36].

The Development of Plant Meat in China

Recent development in China

China's abundance of plant-based meat raw materials presents unique opportunities for the development of this industry in a predominantly agricultural country. Despite plant-based meat having a longstanding history in China, its market development lagged behind that of western countries. In 2018, the artificial meat industry began to emerge in China with the introduction of start-ups. Subsequently,

in 2019, Hong Kong-based plant-based meat company, OmniPork, penetrated the Chinese mainland market [37], increasing consumer awareness and acceptance of synthetic meat products. That same year, China’s first plant-based meat venture company, Jane Meat, was founded and launched its first product, Artificial Moon Cake [38]. Other plant-based meat products, such as week zero’s plant-based hamburger and Qishan’s plant-based pork, were also introduced, opening up the possibilities for Chinese plant-based meat products to reach a wider audience [39]. 2020 can be called “the first year of plant meat in China” [40], and the market for plant meat is booming. A survey conducted by DuPont in the United States in 2020 pointed out that China is one of the countries with the fastest growth rate in the plant protein market in the world [41]. Beyond Meat opened a factory in China that same year, and the domestic artificial meat market has rapidly expanded into e-commerce, restaurants, and supermarkets [36].

However, with this rapid development, there have been varying consumer opinions on plant meat products. The plant meat industry has begun to research and develop new products. China plant meat development direction has a new blue sea-microbial protein plant meat [15,42]. Edible fungus has high protein content and a distinct flavour that can imitate meat more easily than soybean, grain, and other plant products. This innovation sets China apart from other countries in the plant meat industry.

Scholars have found that the United States, China, and India exhibit high acceptance rates for plant-based meat products, with domestic consumers expressing a willingness to repurchase [42,43]. As a populous country, China boasts a sizable plant meat market [44]. Therefore, it is crucial to identify the factors that drive the development of plant-based meat in China. This study focuses on three key elements: global environmental and animal welfare concerns [14,45], government policies and regulations, consumer demand and health demand health [32,35].

Environmental and animal welfare issues have promoted the development of plant meat

China consumes a tremendous amount of meat, which caused a series of problems [46]. First, water and soil resources need to be increased, and traditional animal husbandry has also reached the development bottleneck. In Reijnders’s research, the land resources needed for conventional meat production are several times or even ten times more than those required for plant meat product production [47]. Replacing traditional meat with plant-based alternatives can reduce land requirements by up to 15%. Livestock contributes to about 14.5% of total greenhouse gas emissions [48], and dietary changes can help address this issue [49]. Studies indicate that a vegan diet could cut greenhouse gas emissions by 25% to 55% and reduce land use by 50% to 60%. Moreover, replacing some animal meat with plant-based options may also lower greenhouse gas emissions by 5% and land use by 15% [8,50]. Studies suggest that positive attitudes towards plant-based diets and consumer awareness about the environmental impacts of animal husbandry are vital factors in driving sustained demand [11,51]. Therefore, from the aspects of saving various resources and protecting the environment is, plant meat bound to occupy a significant position in China.

Second, incomplete statistics indicate that humans slaughter 200 million animals daily and 72 billion annually [52]. As animals possess

a degree of consciousness, many developed nations have established laws to address animal welfare concerns [53]. China similarly places importance on animal welfare [54], with a fundamental policy of promoting harmonious coexistence and sustainable development between humans and nature. The Chinese government has endeavored to establish standards and regulations for animal welfare to tackle issues related to animal slaughter and poaching [55]. Nonetheless, in comparison to developed Western nations, China’s regulations on animal welfare remain inadequate and disjointed [54]. The expansion of meat consumption necessitates the adoption of plant-based alternatives to address animal welfare issues, particularly amid the ongoing ethical discourse concerning meat production [56].

Government policies and regulations

The trend of humans prioritizing the environment, health, and animal welfare is driving the growth of plant-based meat [43]. First, the Chinese government has implemented policies to support this development, such as promoting the green economy [57]. China’s 13th Five-Year Plan emphasized the value of natural resources and the importance of green development in supply-side structural reform [58]. The Tenth Five-Year Plan highlighted the goal of developing green finance, supporting technological innovation, and upgrading key industries to achieve sustainable economic and industrial development [59]. In February 2021, the State Council released the “Guiding Opinions on Accelerating the Establishment and Improvement of a Green and Low-Carbon Circular Development Economic System” to support the development of a sustainable economy. This document emphasizes the importance of promoting a green, low-carbon, and circular economic system, as well as encouraging green industry enterprises to access the capital market [60]. China’s five-year agriculture plan, unveiled in the same year, prioritizes promoting alternative meat technologies using plant protein and farmed meat. This aims to enhance sustainability and food security and reduce the environmental impact of agriculture [13,43]. China has implemented several policies to drive green development in recent years, as shown in Table 1.

Time	Document	Authority
2016/10	“Tutorial for Outline of the Healthy China 2030 Plan”	General Office of the State Council, PRC
2017/2	“The 13th Five-Year National Food Safety Plan”	General Office of the State Council, PRC
2017/6	“Overall Plan for Building a Green Finance Reform and Innovation Experimental Zone in Guangzhou, Guangdong Province”	General Office of the State Council, PRC
2017/12	“Report on the deliberation results of the motion submitted by the deputies to the Fifth Session of the Twelfth National People’s Congress by the Presidium”	National People’s Congress
2019/4	“Opinions on innovating management, optimizing service, cultivating and expanding new kinetic energy for economic development and accelerating the continuous transformation of old and new kinetic energy”	General Office of the State Council, PRC

2020/9	Revision of the “Green development of the Yangtze River Economic Zone special central budget investment management Interim Measures”	National Development and Reform Commission
2021/2	“Guidance on Accelerating the Establishment and Perfection of a Green and Low-carbon Circular Economic Development System”	General Office of the State Council, PRC
2022/1	“Opinions on Improving the Green and Low-carbon Transformation System, Mechanism and Policy Measures of Energy”	National Energy Commission & National
		Development and Reform Commission
2023/1	Green Development of China in the New Era (White Paper)	The State Council Information Office

Table 1: China’s Green Economy Policies from 2017 to 2023.

Second, the promotion of a two-carbon (peak carbon dioxide emissions and carbon-neutral) policy. In September 2020, China explicitly proposed the “peak carbon dioxide emissions” in 2030 and the “carbon neutral” goal in 2060 based on the internal requirements to promote the realization of sustainable development and the responsibility to build the Community of a Shared Future for Mankind [61]. As the world’s second-largest economy, China has actively participated in the global crisis response to the severe global warming crisis. The dual carbon policy is proposed to improve the transformation of green financial enterprises further and promote the development of green and low-carbon enterprises and products.

Third, the popularity of Greater Food. The “Greater Food” was mentioned in document No.1. Establishing the concept of the big food view is better to meet the needs of people and better life. It “ asks for heat and protein from cultivated land, grassland, forest and sea, and from plants, animals, and microorganisms, and developing food resources in all-round and multiple ways” [62]. People’s concept has changed from “having enough to eat” to “having good food,” emphasizing food quality and health. The increase in soybean and oil production is a specific manifestation of the concept of the big food view.

In general, whether the proposal of a green economy development strategy, the formulation of a two-carbon target, the popularization of a large food concept, or the submission of more key green policies, the labeling characteristics of green, healthy, economic and environmental protection of plant meat products are perfectly consistent with the policies of China [12,63].

Consumer demand and health demand

China’s urbanization and economic development led to the improvement of diet structure, the increase in meat consumption, and the increasing pressure on China’s animal husbandry, which led to more major environmental problems and animal welfare problems [49]. The domestic meat supply cannot meet the needs of consumers, so the China market needs a third channel to alleviate this problem. Additionally, the overconsumption of meat has led to health concerns in the country [43].

African swine fever [63,64], bird flu, and other diseases broke out in China, causing public safety accidents. Additionally, the

consumption of meat high in saturated fatty acids may increase the risk of chronic diseases [43]. The heme iron present in meat may elevate the risk of gastric and esophageal cancers [65], while high salt intake is associated with elevated blood pressure levels [8,48,66]. A recent study by Oxford University researchers revealed that the excessive consumption of red and processed meat can increase the risk of 25 diseases including ischemic heart disease, diabetes, pneumonia, and colon polyps. The study also found that higher intake of poultry meat is linked to increased risks of gastritis, gastroesophageal reflux disease, gallbladder disease, duodenitis, and diverticular disease [48,67]. Previous research suggests that shifting to a plant-based diet can benefit both human and environmental health, reducing the risk of diabetes, heart disease, and stroke [68]. Structural surveys indicate that a global shift toward plant-based diets could decrease mortality rates [69]. Consequently, the development of plant-based meat alternatives is critical for public health and consumer wellbeing.

Factors Affecting Chinese Consumers’ Acceptance of Plant-based Meat

Research suggests China will be the world’s largest market for plant-based meat products, with 39% of Chinese consumers keen to reduce their meat intake [70]. However, catering to Chinese tastes remains a significant challenge for veggie-meat suppliers. Describing China’s adoption of plant-based meat is complex due to the limited research available on the topic and current research focusing on a small subset of Chinese consumers. This paper provides a summary of recent research published in the past three years on Chinese consumers’ acceptance of plant-based meat, as presented in Table 2. The critical factors that affect consumer acceptance can be roughly divided into three categories.

Study Subject	Participants	Main Parameters:	Reference
Non-vegetarian	223 participants from China.	Gender; Age; Education level; Occupation; Internet communication channels; Interpersonal communication channels; Social environment; Individual characteristics; Take action	[71]
Artificial plant meat products	6906 participants from China	Knowledge level; Attitude; Sensory pursuit; Health motivation; Purchase intention	[72]
Artificial plant meat products	197 college students in Shanghai	Gender; Grade; Major; Monthly living expenses level; College students’ consumption status of plant meat products; College students’ views on plant meat products	[73]
Consumers of KFC Artificial Meat Products over the Age of 16	202 Respondents in Wuhan City	Taste; Technical sub-insurance; Perceived experience; Perceived usefulness; Perceived trust; Purchase Intention	[74]
Artificial plant meat products	3691 participants from China.	The frequency of consumption in daily life; Willingness to buy plant meat; Requirements on the quality of artificial meat; Factors Influencing Consumers’ Preference for Plant Protein	[75]

Table 2: Study that purchase attitude of China consumers to plant meat.

Social demographic

The acceptance and intention to purchase plant-based meat are affected by consumers’ gender, income, and education [71,72]. Females are more likely to purchase because they prefer healthy and low-fat diets. Higher income is also a factor, as consumers with more

financial power are likelier to overlook the high production cost and purchase plant-based meat products [72]. Education levels have varying impacts on consumer understanding of plant-based meat, with promoting knowledge and awareness crucial to improving purchase intention [71].

Product factors

These studies suggest that the price, taste, and texture of plant meat products are the three key influencing consumer purchasing decisions [73-75], with price having the most significant impact [74]. However, due to technical limitations, plant meat products' production costs and market prices remain high, which deters consumers from buying them [72,73]. According to the report of Mintel, a consulting company, about two-thirds of consumers know and are willing to try plant meat. However, some less wealthy consumers who initially showed interest began to waver when they saw high prices. On the other hand, consumers also hope that plant meat products can closely resemble traditional meat in appearance, texture, and taste while maintaining high nutritional value, quality, and safety standards [72,74,75].

Consumer perception

Personal beliefs [8,71,75] and health concepts [71,72,75] largely influence people's choice of plant-based meat. Vegetarians have a stronger preference for plant protein, and religious cultures such as Buddhism further promote the adoption of plant-based meat [71]. Non-vegetarians' interest in vegetarian brands affects their acceptance of plant-based meat. The health theme of a vegetarian diet is widely accepted, with consumers' greater focus on dietary health [75]. Tang's research shows that 53.14% of the sample chose plant-based options for health purposes [71], while Jiao Xinli found that women were more likely to choose plant-based meat due to their greater emphasis on health [72].

Policy Implication

China's plant-based meat market has great potential for growth and needs further exploration. To better understand the connection between the two, this study looks at the development of plant-based meat historically, three drivers of growth in China, and factors influence consumer acceptance. The study found that Chinese consumers have a historical and cultural fondness for plant-based meat, while a clear policy or development plan for the industry are still needed.

The future strategy for the plant meat industry

For long-term and high-quality development of plant meat industry, consumers' attitude towards plant meat is essential [35]. Prior studies confirmed that Chinese consumers pay more attention to health, flavor, taste, texture, and price [44]. Therefore, the core strategy is to change the attitude of consumers by carrying out a series of activities. For example, the "Monday vegetarian meal" plan launched by Xiamen restaurant every week [73], which can positively influence college students' views on plant meat and is also consistent with the strategy of implementing a meat-free working day in the West [33]. Besides, consumers' attitudes towards plant meat have been constantly changing in recent years [35]. The popularity of vegetarians and low-calorie diet offers a great opportunity for plant meat enterprises to expand market.

China government's response to the development of plant meat

The diet structure has been upgraded with the improvement of the consumption level in China [42]. Effectively supplementing the meat market and ensuring the regular transformation of the diet structure are current problems that the Chinese market must face. First of all, the plant meat market in China is growing [42]. Most consumers choose plant meat precisely because of its healthy, green, safe, and sustainable label [12,76]. Therefore, food regulatory agencies must be required to strengthen supervision over the production of plant meat products [77,78] and implement practical policy tools, such as improving relevant laws and regulations, price policies, information services, and dietary guidelines [79].

Secondly, food authorities need to enhance their support for plant meat enterprises [42], in order to effectively compete with foreign counterparts such as Beyond Meat and Impossible Foods. This support should cultivate leading domestic plant meat companies and gain a competitive position in the global market. In addition, the demand for raw materials for plant meat production is increasing. Promoting more grain and developing the plant meat industry positively impact China's grain reserves [42] and help maintain the achievements of the fight against poverty [80]. Therefore, the popularization of plant meat will require the necessary adjustment of the agricultural planting structure in China.

Finally, in rural areas of China, consumers still have strangeness and prejudice towards plant meat. Therefore, long-term social education is needed to shape consumers' cognition of plant meat and improve their image in citizens' minds [12, 35], which is a long-term educational task.

Conclusion and Future Research

Plant-based meat is gaining popularity due to concerns about animal welfare, the environment and health. China's large meat consumption market is facing the challenge of finding an alternative to traditional meat. Therefore, food enterprises are exploring plant-based meat, which is gaining traction in China. Studies show that by 2050, plant-based meat may substitute up to 6.7% of traditional meat in China, replacing more than 13 million tons of meat products and saving over 46 million tons of feed grains.

The plant meat market in China has excellent growth potential and needs further exploration. To better understand the relationship between the two, this study focuses on the history and development of plant meat alternatives, the development of plant meat in China, policy drivers and factors that affect consumer acceptance in China, and strategic suggestions to the government and plant meat enterprises. It is found that consumers in China have a historical and cultural preference for plant meat. Still, the historical relationship between people in China and bean products makes consumers have a higher demand for plant meat. Although consumers' acceptance of plant meat has increased in recent years, it is urgent for China, a country with a population of 1.4 billion, to continuously promote the depth and breadth of consumers' acceptance of plant meat products and optimize the quality of plant meat products. As a new and developing product category, plant meat is facing opportunities and challenges in China market, including cultural, sensory, and policy factors. By adopting strategic suggestions to meet these challenges, plant-based meat enterprises can seize the opportunity and contribute to China's more sustainable, healthier, and ethical food system.

Limitation

Our study suffers from some limitations. First of all, this study focuses on the Chinese market, which may limit its applicability to other countries/regions. Next, the plant-based meat market is developing rapidly, our conclusions are open to refine. What's more, the data in this study are essentially a compilation of secondary data, which may create bias. Therefore, future research can collect primary data through methods such as questionnaires and case study. Finally, there is still space for both the Chinese market and food safety policy. Future research must design longitudinal study to observe the trends of factors of consumer behavior and the development of plant-based meats in greater detail.

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