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EDITED BY

Umer Farrukh,
Government College Women University Sialkot,
Pakistan

REVIEWED BY

Çağatay Yıldırım,
Ondokuz Mayıs University, Türkiye
Muhammad Imran,
University of Veterinary and Animal Sciences,
Pakistan

*CORRESPONDENCE

Shengze Qin
✉ Shengzeqin@foxmail.com

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Cultivating a greener plate: understanding consumer choices in the plant-based meat revolution for sustainable diets

Sahar Erfanian¹, Shengze Qin^{2*}, Liaqat Ali Waseem³ and
Muneer Ahmed Dayo⁴

¹Business School, Huanggang Normal University, Huanggang, China, ²School of Tourism Management, Wuhan Business University, Wuhan, China, ³Department of Geography, Government College University Faisalabad, Faisalabad, Pakistan, ⁴Department of Education, Shaheed Zulfiqar Ali Bhutto Institute of Science and Technology (SZABIST), Karachi, Pakistan

The implementation of sustainable food systems on a global scale is of utmost importance in order to effectively achieve sustainable diet goals on a world level. Plant-based meat alternatives offer potential replacements for meals derived from animals and serve as a means to transition toward more environmentally sustainable dietary choices. Therefore, in the quest for sustainable diets, comprehending consumer behavior and preferences within the context of the plant-based meat revolution is crucial. The current study is planned to examine the factors that influence the acceptance of plant-based meat alternatives among Chinese people. For this purpose, data collected from 610 individuals through an online survey was analyzed using the partial least square structural equation model. The findings reveal that consumer perceptions, particularly regarding taste, nutrition values, and texture, were found to have a significant impact on the acceptance of plant-based meat alternatives. Effective promotional strategies, availability, and accessibility also play a vital role in influencing consumer preferences for plant-based meat alternatives. The outcomes regarding the significance of health perception and environmental concern in transforming consumer preferences for plant-based meat alternatives are also highlighted. Consumers prioritize plant-based meat alternatives due to their perceived health benefits and favorable environmental impact. Moreover, consumer satisfaction, rooted in meeting or exceeding expectations, signifies the mediating role in the relationship between consumer perceptions and the acceptance of plant-based meat alternatives, which boosts the plant-based meat alternatives' acceptance. Furthermore, the findings underline the mediating role of environmental attitude in the relationship between environmental concerns and plant-based meat alternatives' acceptance, emphasizing the importance of sustainable dietary choices. In general, these findings provide valuable insights into the promotion of sustainable dietary choices, the alignment of consumer behavior with environmentally conscious decisions, and transforming the food systems in light of changing consumer behavior and ecological concerns.

KEYWORDS

sustainable diets, sustainable food systems, consumer behavior, plant-based meat alternative, healthy nutrition

1 Introduction

Food systems possess the capacity to foster human well-being and uphold ecological sustainability, yet their present state poses a dual jeopardy to these objectives. The immediate challenge lies in ensuring that a burgeoning global population is afforded access to nutritious diets through the implementation of sustainable food systems. The lack of established scientific objectives for attaining nutritious meals within sustainable food systems has impeded widespread and coordinated endeavors to revolutionize the global food systems. A considerable body of research indicates that current global food systems and eating practices are not sustainable in terms of both human and ecosystem well-being (Willett et al., 2019). The food systems are responsible for 21–37% of global GHG emission and world agriculture is responsible for 70% of freshwater usage (Food and Agriculture Organization, 2013; Shukla et al., 2019). Furthermore, it is important to note that there are multiple leverage points within the global food systems, encompassing various aspects such as agricultural production and waste management. These leverage points possess the capacity to bring about significant transformative impacts. Nevertheless, it is improbable that the agriculture sector in isolation will be capable of achieving global climate targets without a simultaneous and substantial modification in consumer food habits (Theurl et al., 2020).

Meat has long been recognized as a significant constituent of the healthy diets, serving as a valuable reservoir of vital nutrients necessary for the processes of human development. Meat farming and processing contribute to employment and revenue creation in addition to their nutritional significance. In the past few years, there has been a growing focus on the sustainability of meat production and the potential negative impacts of animal husbandry and meat intake on the natural world and the well-being of humans. This has led to greater concern about the negative effects of meat production on the environment and human healthiness (Riley, 2010). The production of traditional meat through animal husbandry has been linked to various significant environmental issues, such as emissions of greenhouse gases, forest loss, and freshwater usage (McMichael et al., 2007).

The production of livestock is responsible for a significant proportion, ranging from 14 to 30%, of GHG emissions caused by human activities (Reisinger and Clark, 2018). Additionally, it is the primary source of methane emissions resulting from human activities. Meat farming also necessitates a disproportionate allocation of land and precious resources in comparison to other food sources (Alkon, 2014). Certain methods of cow production, such as those under consideration, necessitate the use of around 25 kg of animal feed and 15,000 L of water in order to yield 1 kg of meat (Mekonnen and Hoekstra, 2010). With the growing demand for meat, there is a mounting imperative to adopt intensive agricultural methods, such as feedlots, instead of relying on pastoral grazing. The rise in demand for animal feed, primarily sourced from extensively cultivated grain crops like maize and soy, has been identified as a significant factor in the occurrence of deforestation in regions such as the Amazon (Food and Agriculture Organization, 2013).

Numerous credible organizations have advocated for meat reduction for wholesome and sustainable food systems, acknowledging the related harms. In order to keep global warming due to human activity below 2°C, the IPCC has urged for a global food systems response that includes significant dietary changes as well as decreases

in meat production and consumption (IPCC, 2018). An estimated 10.9 to 11.6 million fatalities annually might be avoided by switching to a nutritious and environmentally friendly diet that includes less meat and switching to a meat alternative such plant-based meat alternative (PBMA) (Willett et al., 2019).

It is anticipated that the worldwide market for PBMA will experience significant growth, with a predicted value of \$85 billion (USD) by the year 2030 (Gordon et al., 2019). The promotion of PBMA is frequently advocated as a way to address the sustainability issues, animal welfare concerns, as well as in certain instances, public health issues linked to the farming and consumption of traditional meat. This approach aims to attract consumers by utilizing established supply chains. There is an increasing recognition among scientists that it is crucial for nations with a high intake of meat to make significant transitions toward sustainable diets that prioritize PBMA. This is necessary in order to effectively achieve climate change mitigation targets (Bajželj et al., 2014; Bryngelsson et al., 2016) and stay inside the limits of what the planet can sustain (Willett et al., 2019). Collectively, these apprehensions have motivated endeavors to diminish the use of traditional meat and enhance PBMA consumption.

PBMA provide a possible answer to the issues involved with shifting dietary patterns away from animal products worldwide. These dietary modifications frequently entail changes in meal composition and the acquisition of new cooking skills, which might be seen as barriers to a PBMA transition (Macdiarmid et al., 2016). PBMA is designed to closely replicate the sensory characteristics, particularly flavor and texture, of their animal-based meat.

The future implementation of large-scale sustainable meat production, which does not involve the use of animals, has the potential to address numerous ethical, environmental, and health-related issues that are now linked with the raising of animals (Bryant and Barnett, 2018). In recent years, there has been a growing acceptance of PBMA as a feasible substitute for traditional meat due to advancements regarding quality and its rising popularity among consumers (Wild et al., 2014). Nevertheless, the advantages of these products can only be fully realized if they effectively replace the need for traditional meat. A substantial 73% increase is projected in global meat demand by the year 2050 with a significant portion of this growth expected to originate from emerging nations. However, it is disconcerting to note the limited extent of studies conducted on consumer attitudes toward PBMA in developing countries.

China and India have been recognized as key nations for conducting consumer research on PBMA (Bryant and Barnett, 2018). These countries possess the largest populations globally and are anticipated to experience a surge in their meat consumption in the forthcoming decades due to the growth of their economies, enabling a greater number of people to afford meat. Moreover, it is important to acknowledge that there are significant cultural disparities between the developed and developing countries, which has been the primary focus of consumer acceptance research. Consequently, it is likely that consumer acceptance in China may exhibit distinct characteristics. There is a dearth of scholarly investigations pertaining to the level of consumer acceptance of PBMA in the Chinese market. Thus, this study aims to explore acceptance of PBMA for sustainable diet and identify the factors associated with their acceptance.

Understanding and viewpoints from consumers will be crucial for a PBMA's future market acceptability, even though customers may give less priority to the matter when the PBMA is unavailable and its

availability duration is uncertain (Goodwin and Shoulders, 2013). Consumers may not be as excited about developing agro-food technologies during their research and deployment stages, as seen in numerous recent examples such as biotechnology and nanotechnology (Verbeke et al., 2015). Consumers are receptive to non-invasive processing technologies that enhance the health and taste of meat, as reported by De Barcellos et al. (2010). However, strong opposition is shown to interventions and changes in the meat production chain that are viewed as excessive, invasive, or otherwise departing from natural processes.

This study is one of a few that explores consumer behavior related to the acceptance of PBMA for sustainable diets and food security in developing countries. PBMA can greatly contribute to addressing sustainable dietary intake and transitioning toward sustainable food systems that fulfill food security requirements worldwide. Additionally, exploring the potential of plant-based meat alternatives can enable individuals to meet their food security demands. This study looks into how consumer behaviors related to meat consumption have changed in favor of PBMA. What factors shape the consumer behavior in favor of PBMA. Thus, the current study is planned to examine the factors that influence the acceptance of PBMA among Chinese people. This research offers insightful information for decision-makers looking to observe consumer behavior in support of sustainable diets and food consumption. This study makes a substantial contribution to the expanding body of scientific literature that aids in our comprehension, prediction, and avoidance of possible adverse effects on people's future environmental inspirations and behavioral patterns brought on by conventional meat consumption. The findings of this study have significant ramifications for health professionals and legislators who prioritize sustainable food systems and sustainable diets. Government agencies, parties involved in the food supply chain, and nutritionists, who are largely in charge of guaranteeing sustainable diets, are among the study's possible beneficiaries.

2 Hypothesis development

The way that consumers view foods has a big impact on whether or not they are accepted. A number of elements, such as sensory qualities, esthetic appeal, flavor, texture, freshness, and safety, influence how consumers perceive a particular food. Customers' willingness to accept a food may be adversely affected if they believe it to be inferior to alternatives (Lim et al., 2014). The appeal of meals and consumers' opinions of their perceived safety and quality affect their purchasing decisions. PBMA and their analogs in processed meat are viewed similarly (Michel et al., 2021). This study also states that customer perception plays a major role in determining PBMA acceptability as sustainable diets and transition toward sustainable food systems.

H1: Consumer perception significantly affects the acceptance of PBMA.

Only a small percentage of consumers regularly purchase and consume PBMA products (Hagmann et al., 2019; Siegrist and Hartmann, 2019). On the other hand, a great majority of individuals do not take PBMA seriously (Lemken et al., 2019). According to a

study by Hoek et al. (2011), people who regularly eat PBMA are largely responsible for the positive results related to the acceptance of PBMA. Participants were asked to rate the flavor, texture, look, and aroma of both meat and PBMA in this study. The results showed that PBMA scored higher than meat among regular consumers. However, those that used PBMA moderately gave more balanced scores, leaning slightly more in favor of traditional meat. However, when compared to PBMA, those without access to meat substitutes gave meat a far higher quality rating (Hoek et al., 2011). Thus, we assume that

H2: Consumer satisfaction positively affects the acceptance of PBMA.

H3: Consumer perception significantly mediates between consumer satisfaction and the acceptance of PBMA.

The production and consumption of animals have been identified as significant contributors to various environmental challenges that pose a threat to sustainability. These challenges include GHG emissions, land use and degradation, water consumption, soil pollution, and food waste at the consumer level throughout all stages of the food supply chain (Magkos et al., 2020). The contemporary food system exhibits a notable environmental footprint, often linked to heightened levels of livestock farming and over consumption (de Boer and Aiking, 2011; Hoek et al., 2011). Curiously, notwithstanding this apparent disinterest, scholarly investigations indicate that a considerable proportion of individuals who partake in meat consumption recognize the possible advantages associated with adopting a vegan or vegetarian dietary regimen, particularly in relation to the well-being of cattle and the promotion of environmental sustainability (Bryant, 2019). The increasing recognition of the known environmental advantages associated with reducing the use of animal-sourced food has resulted in a surge in the acceptance of plant-based alternative food, particularly in industrialized countries (Fresán and Sabaté, 2019). According to Saerens et al. (2021), PBMA has a lesser negative impact on the environment compared to most forms of meat production. This is mostly attributed to the reduction in refining losses that occur within the animal production process. According to Alae-Carew et al. (2022), the concept of PBMA holds significant potential in the context of climate change mitigation, particularly in relation to the establishment of a sustainable food system and sustainable diets. According to Smetana et al. (2023), individuals who express a preference for the importance of environmental stewardship are more inclined to engage in pro-environmental behavior. Hence, it is postulated that:

H4: Consumer environmental concerns significantly affect the acceptance of PBMA.

H5: Consumer environmental concerns significantly affect consumer environmental attitude toward PBMA.

Further we hypothesize that

H6: Consumer environmental concerns mediated between consumer environmental attitude and acceptance of PBMA.

Over the course of recent decades, health organizations have issued recommendations advocating for the augmentation of whole plant food consumption (Rock et al., 2020). Adhering to this dietary recommendation is linked to decreased chances for diabetes, cancer, cardiovascular disease, and overall mortality to differing extents (Aune et al., 2017). In recent times, there has been an increased emphasis on the health advantages associated with substituting animal protein with (Abdelhamid et al., 2018). PBMA are commonly regarded as having a higher level of healthiness compared to meals derived from animals (Schiano et al., 2020; Profeta et al., 2021). The acceptance of plant-based diets is imperative in order to achieve a sustainable dietary pattern that can effectively contribute to beneficial outcomes in terms of environmental preservation, human health, and public health (Springmann et al., 2018). There is evidence to suggest that PBMA are frequently considered to be comparatively healthier than meals derived from animal sources (Michel et al., 2021). Alae-Carew et al. (2022) provide evidence indicating that a decrease in the intake of traditional meat would be in line with priorities for promoting health. Consequently, we postulate that

H7: Health perception significantly affect the acceptance of PBMA.

The role of marketing is crucial in shaping consumers' views and fostering their acceptance of sustainable diets. The marketing strategies employed for promoting products have the potential to shape consumers' perceptions and willingness to adopt novel food items, such as PBMA (Sucapane et al., 2021). Consequently, marketing practices significantly impact customers' choices when it comes to purchasing food. The marketing mix encompasses a variety of elements that are taken into account during the marketing of a product, such as the assessment of consumer preferences, the perception of the product, and its differentiation from competing products. In the context of food goods, several elements contribute to their marketability, including product descriptors and images shown on the packaging, pricing, as well as in-store placement and promotional strategies (Brooker et al., 2022). Therefore, it is assumed that

H8: Promotion strategies of PBMA can positively influence the acceptance of PBMA.

The potential for altering consumption patterns appears promising through the enhancement of the relative accessibility of PBMA in comparison to animal-derived meat (Raghoobar et al., 2020). There is a growing recognition that the arrangement of physical food environments significantly influences the shift toward more sustainable and nutritious dietary patterns, rather than solely attributing responsibility to consumers and focusing solely on conscious factors that influence behavior (Bianchi et al., 2018). Research has demonstrated that the physical attributes of environments have a significant impact on individuals' meal choices within these specific dining contexts. In-store availability of food has been consistently recognized as a significant determinant of food selection, as evidenced by the findings of Pitt et al. (2017). The concept of in-store food availability pertains to the frequency of product occurrences within the tangible retail setting (Pechey et al., 2020). Numerous studies have examined the relationship between

food availability and consumption, specifically focusing on the effects of increasing the availability of low-calorie foods while reducing the availability of high-calorie foods in order to promote the selection of healthier food options (Hollands et al., 2019). Insufficient scholarly focus has been devoted to comprehending the factors that determine the impact of food availability on the consumption patterns of more sustainable food options. Based on our hypothesis, it is postulated that

H10: Availability and accessibility of PBMA in food markets can positively influence its acceptance.

3 Materials and methods

3.1 Questionnaire design

Researchers studying the acceptance of new food products among consumers have frequently used questionnaire surveys to collect primary data. We first conducted a thorough assessment of the relevant scholarly literature and then solicited the feedback of academic and research specialists familiar with the subject area to construct the survey instrument for this study. An approach consisting of two stages was used to determine whether the questionnaire was suitable for the survey and whether it could be relied upon. At first stage, a group of five academic professionals, including professors, associate professors, and researchers, conducted an in-depth review and analysis of the questionnaires. These people were expert in the field of consumer behavior. The purpose of the study was to determine the extent to which the questionnaire included all relevant information and to assess how understandable the technical terminology was. In addition, a sample group consisting of twenty-five individuals was used for the initial evaluation. Consequently, changes were made to the questionnaire after it had already been completed. These changes were incorporated into the final questionnaire, and a well-designed questionnaire was used to collect the data for the study.

Eight constructs were measured in this study: (i) Consumer perceptions about PBMA (CPE), (ii) promotion strategies of PBMA (SFP), (iii) health perceptions (HPE), iv) environmental concerns (ENC), (v) acceptability and availability of PBMA (AAA), (vi) consumer satisfaction (CS), (vii) environmental attitude of consumers (ENAT), and (viii) PBMA acceptance. The first section of the questionnaire measured PBMA-related consumer perceptions using seven statements. The second section of the survey instrument included five queries related to PBMA promotion strategies. The third and fourth parts of the questionnaire measured the health perception and environmental concerns of consumers through nine and eight statements, respectively. The next two sections measured the accessibility, availability, and consumer satisfaction about PBMA. The seventh section examines the environmental attitude of consumers by using five questions. The acceptance of PBMA was measured through seven well-designed questions. The last section of the questionnaire focused on the socio-demographic characteristics of the consumers. A five-point Likert scale was used to evaluate responses to all questions in the survey instrument, with the exception of the first socio-demographic section.

3.2 Data collection

A questionnaire survey was undertaken utilizing an Internet-based platform to gather responses from individuals representing diverse socioeconomic characteristics in response to the COVID-19 regulations in China. An additional rationale for employing online surveys as a means of gathering data is the cost and time constraints associated with conducting in-person surveys, which may also yield a sample that is not representative of the population under study (Cooper et al., 2012). According to Frankfort-Nachmias and Nachmias (2008), questionnaire surveys require the involvement of skilled interviewers who can pose questions and gather unbiased information. Consequently, substantial investments in training are required to cultivate a proficient team that incurs both temporal and financial expenses. As a result, the decision was made to utilize online data collection methods to enhance the scope of the survey and encompass a more diverse range of participants from various cultural backgrounds.

Thus, information was gathered using an online survey presented to a sample of people recruited in China. Participants were given a link to the survey, which was developed using Google Forms. The samples were screened to evaluate the level of meat consumption. Participants who stated that they did not consume meat” and/or failed the attention and quality check questions were excluded from the study. 4.6% of the respondents stated that they did not consume meat. It was deemed necessary to incorporate a particular level of meat consumption to assess the consumer evaluation and acceptability of PBMA. Following the completion of these tests, the study included 610 questionnaires that were declared complete and acceptable for the analysis.

3.3 Statistical methods

The collected data were analyzed using the structural equation model (SEM) amalgamates the advantageous features of factor and path analysis, thereby resulting in a potent multivariate statistical instrument. The application of Structural Equation Modeling (SEM) is an approach to statistics that facilitates the analysis of the interrelationships among various effects, various influences, and latent variables. It integrates various analytical methods such as analysis of variance, factor analysis, regression analysis, and path analysis (Hair et al., 1998; Byrne and Stewart, 2006; Hair et al., 2006). All variables examined in this study exhibited interrelatedness, either as latent variables or through their interaction. The PLS-SEM methodology is a type of multivariate structural equation modeling that is classified as a second-generation approach. According to research, the use of non-parametric methods in studies with limited sample sizes can eliminate distribution assumptions and yield greater statistical power compared to other methods (Hair et al., 2012). The process of reducing and validating constructs prior to constructing the ultimate structural equation for each obvious variable enables the simple verification of item validity through the use of PLS. Previous literature has established that a minimum of 100 respondents is required to achieve impartial results when utilizing this particular model (Reinartz et al., 2009). Moreover, the adequacy of the respondents for this model was established through Hair et al.’s (2017) ten times rule and G*power. The present study heavily relied on the analytical approach put forth

by Hair et al. (2017). As Chin (2009) indicates, the PLS-SEM methodology consists of a measurement model and a structural model.

4 Results

4.1 Background of respondents

Table 1 shows the respondents’ sociodemographic characteristics. The average age of the respondents was more than 42 years, and a large majority of the respondents were aged between 26 and 50 years. Similarly, a large majority of the respondents had an education level between 10 and 16 years. The average family size was greater than three members in the study area. More than half the respondents participating in this study were married. More than two-fifths of the respondents resided in the rural areas of China. The mean monthly income of respondents was estimated to be more than 12,000 yuan.

4.2 Descriptive analysis of latent variables

Supplementary Table 1 describes the results evaluating various aspects related to the acceptance of plant-based meat alternatives (PBMAA) among consumers for sustainable diets. Regarding PBMA, the findings signify that, on an average, respondents perceived a moderate level of acceptance, with a mean score of 3.72. Notably, a mode score of 4 indicates that most respondents perceived a moderately high level of PBMA acceptance. The results are generally optimistic, with a mean score of 3.98 regarding consumer perception (CPE). This implies that consumers hold positive perceptions of PBMA. A mode of 4 supports this, which describes that most of the respondents indicated positive perception about PBMA. The mean score of 4.50 of strategies for promotion (SFP) signifies the effectiveness of promotional strategies for PBMA as sustainable diets. With a mode of 5, mostly respondents rated SFP with “strongly agree,” which indicates their potential impact on consumer choices for

TABLE 1 Respondents’ background.

Variables	Frequency/Mean
Age	
<25 years	177
26–50	352
>50	81
Mean	42.32 (11.23)
Education	
<10 years	149
10–16 years	442
>16	19
Mean	12.28 (3.21)
Family size (members)	3.57 (0.87)
Marital status (1 = Married)	307
Residential area (1 = Rural)	270
Monthly income (Yuan)	12230.76 (3287.16)

Values in parenthesis are standard deviation.

PBMA. The HPE associated with PBMA are generally positive, with a mean score of 4.06. The mode of 4 and 5 signifies that majority of respondents held optimistic views about the health aspects of PBMA, which highlights the perceived health benefits. Respondents, on average, indicated a moderate level of environmental concern regarding PBMA, with the mean score of 3.28. The responses show notable variation, and the standard deviation indicates that there is some diversity of opinion. AAA had a mean score of 3.68, describes those consumers found modest level of accessibility and availability. The mode of 4 indicates that the majority of respondents rated AAA positively.

4.3 Instruments internal consistency, reliability, and convergence validity

As usual, we used the standard procedure in PLS-SEM to look at a number of factors, such as factor loadings, composite reliability (CR), and average variance extracted (AVE), to find out the convergence validity (CV). The process of conducting a CV involves evaluating the level of agreement among various measurements, primarily through the utilization of factor loadings (FL). Factor analyses (FL) play a crucial role in the field of SEM by providing quantitative assessments of the associations between observable variables and latent factors. Higher factor loadings mean that the measurement is more valid, which makes it easier to figure out how latent variables affect the observed data and find out if the model is good enough. Prior studies have demonstrated that FL values greater than 0.70 are suggestive of a good CV (Bentler and Bonett, 1980; Cheung and Rensvold, 2002). The CV of the items in the current study was confirmed, as all of them had FL greater than the threshold of 0.70. When the mean explained variance is 0.80 or higher, compared to the variance resulting from measurement error, the construct effectively explains a sizable portion of the variance (Steiger, 1989). This shows strong loadings and CV. The statistical importance of each individual statement's FL is shown in Supplementary Table 2. Given that all items displayed factor loadings above 0.70, it is reasonable to infer the existence of CV.

Cronbach's alpha is a statistical measure used to evaluate the internal consistency of a set of items by quantifying the degree of connection among the items within a certain construct. Cronbach's alpha is a common statistical measure used to check the reliability of instruments, especially when measuring effective constructs (Kollmuss and Agyeman, 2002; Frick et al., 2004). According to previous studies (Davis et al., 2011; Levine and Strube, 2012), a minimum alpha value of 0.70 is typically seen as indicative of reliability when assessing latent variables. In the present investigation, it is seen that all constructs demonstrate Cronbach's alpha values are greater than the threshold of 0.70, hence suggesting robust internal consistency and reliability. The findings, as displayed in Table 2, offer strong evidence about the appropriateness of the scale for further research.

Bentler and Bonett (1980), Cheung and Rensvold (2002), and Su et al. (2023) stated that composite reliability (CR) is a better way to measure internal consistency and reliability than Cronbach's alpha because it takes factor loadings for accuracy into account. A CR coefficient of at least 0.60 ensures construct validity (Fornell and Cha, 1994; Cohen, 2013), while CR scores above 0.70 indicate adequate

model fit (Preacher and Hayes, 2004). Model validity is confirmed with a CR value of 0.80 or higher (Steiger, 1989). All constructs in the current study have CR values greater than 0.80, supporting the continuation of the research.

Carlson et al. (2009) came up with Average Variance Extracted (AVE), which is used to find convergent validity. This is similar to how it is measured by observing how well a construct can capture variance as compared to error. To demonstrate a strong CV, AVE values should exceed 0.50. In this study, all AVEs exceed 0.50, indicating robust CV and a substantial amount of variance explained in the observed variables. Consequently, all constructs exhibit strong internal consistency and reliability, which confirms the presence of CV.

4.4 Discriminant validity of measurement model

Discriminant validity (DV) in PLS-SEM distinguishes between constructs, ensuring statements within the model reliably differentiate one construct from others. The Fornell-Larcker criterion (FLC) and the Heterotrait–Monotrait ratio (HTMT) were used to check the DV, as shown in Table 3. To find the Fornell–Larcker criterion, correlation scores between constructs and the square roots of the AVE for each construct are used. According to Rahman et al. (2021), DV is present when the square root of AVE for a construct is higher than its correlation scores with other constructs.

Additionally, HMR values confirm discriminant validity. HMR values below 0.90 indicate strong discriminant validity (Henseler et al., 2015; Rouf and Akhtaruddin, 2018). Table 3 results confirm DV through both the FLC and HTMT analysis. This underscores the need for separate measurement of each construct, as indicators within each construct have stronger associations with their respective construct.

4.5 Goodness of fit of structural model

Table 4 depicts goodness-of-fit parameters' scores for the structural model and compares them with their threshold values. The Chi-Square to Degrees of Freedom ratio is 2.73, indicating an acceptable fit. The GFI is 0.921, indicating a good fit, while the CFI stands at 0.916, supporting a good fit. The AGFI and NFI values above 0.90 signify improvements over the null model. The RMSEA is 0.071, which also ensures an excellent fit. Overall, the structural model aligns well with the data, confirming that the variable relationships are adequately represented.

4.6 Results of structural model

First, the structural model's ability to predict was tested by looking at the coefficient of determination (R^2), which measures how much variation can be explained. Table 2 displays the R^2 values, with all values exceeding 0.63, indicating the strong predictive powers of each hypothesis. We used the nonparametric bootstrapping method described in Wetzels et al. (2009) to test the hypotheses about the relationships between latent variables. This showed that all of the hypotheses were true.

TABLE 2 Direct impact without mediation.

Path	Beta-value	Std. Err.	t-value	f ²	Q ²	R ²	Decision
CPE → PBMAA	0.503	0.084	6.011	0.668	0.446	0.686	Accepted
SFP → PBMAA	0.385	0.065	5.934	0.771	0.464	0.704	Accepted
HPE → PBMAA	0.432	0.103	4.194	0.992	0.287	0.736	Accepted
ENC → PBMAA	0.295	0.084	3.528	0.309	0.473	0.685	Accepted
AAA → PBMAA	0.309	0.048	6.505	0.942	0.316	0.786	Accepted

PBMAA, Plant-based meat alternatives acceptance; CPE, Consumer perception, SFP, Strategies for promotion; HPE, Health perceptions; ENC, Environmental concerns; AAA, Accessibility and availability.

TABLE 3 Discriminant validity of measurement model.

Fornell-Larcker criterion								
	PBMAA	CPE	SFP	HPE	ENC	AAA	CS	ENAT
PBMAA	0.821							
CPE	0.473	0.800						
SFP	0.284	0.184	0.806					
HPE	0.475	0.382	0.473	0.834				
ENC	0.372	0.463	0.298	0.184	0.840			
AAA	0.563	0.392	0.284	0.284	0.284	0.826		
CS	0.281	0.372	0.184	0.285	0.483	0.483	0.826	
ENAT	0.382	0.294	0.382	0.194	0.382	0.362	0.374	0.836
Heterotrait-Monotrait Ratio (HTMT)								
	PBMAA	CPE	SFP	HPE	ENC	AAA	CS	ENAT
PBMAA								
CPE	0.385							
SFP	0.285	0.483						
HPE	0.285	0.385	0.294					
ENC	0.363	0.248	0.195	0.295				
AAA	0.285	0.362	0.483	0.395	0.392			
CS	0.436	0.483	0.364	0.298	0.294	0.385		
ENAT	0.285	0.184	0.274	0.375	0.194	0.294	0.483	

PBMAA, Plant-based meat alternatives acceptance; CPE, Consumer perception; SFP, Strategies for promotion; HPE, Health perceptions; ENC, Environmental concerns; AAA, Accessibility and availability; CS, Consumer satisfaction; ENAT, Environmental attitude.

The coefficient ($\beta=0.503, p<0.01$) signifies the strength and direction of the association between consumer perception (CPE) and PBMAA, with a magnitude of 0.503. According to Cohen’s categorization [Cohen \(2013\)](#), the f^2 value of 0.668 indicates a medium effect size. This suggests that the CPE can account for about 66.8% of the variance in PBMAA. The coefficient score pertaining to the SFP demonstrates a noteworthy beneficial impact on the PBMAA, with a value of 0.385. The f^2 value of 0.771, which indicates the effect size of the SEP in relation to the PBMAA, is significant. The study revealed a favorable and significant impact of the HPE of consumers regarding PBMA on plant-based meat alternative acceptance. The f^2 value indicates a progressively strong effect size. The coefficient ($\beta=0.295, p<0.0$) indicates that there is a positive and significant relationship between ENC and the PBMAA. The study evaluated the significant and favorable impact of AAA on the PBMAA, with a beta coefficient of 0.309. The calculated f^2 value for the AAA variable, which is equivalent to 0.942, suggests a substantial and statistically significant

impact on the PBMAA. The predictive validity of all hypotheses has also been confirmed. In order to achieve our objective, we have employed the approach proposed by [Fornell and Cha \(1994\)](#). Q^2 values greater than zero imply considerable predictive relevance.

[Table 5](#) presents the results regarding the mediation effect of consumer satisfaction between CPE and PBMAA and of ENAT between ENC and PBMAA. The direct impact of CS on PBMAA was significant, and the impact of CPE on PBMAA is also significant. Similarly, the impact of ENAT and ENC on PBMAA is also significant, while CS and ENAT are incorporated as mediators. Therefore, the findings signifies that the direct path is significant, and inclusion of mediators are meaningful.

Hence, including consumer satisfaction (CS) and environmental attitude (ANAT) as mediators proves to be meaningful. We needed to find out how important indirect pathways are in order to confirm whether CS and ENAT act as mediators between CPE and PBMAA and ENC and PBMAA. To assess the significance of these indirect paths, we extracted

TABLE 4 Goodness of fit parameters of structural model.

Parameters	Critical values	Computed values
χ^2/df	<3.0	2.830
GFI	>0.90	0.943
CFI	>0.90	0.918
AGFI	>0.90	0.930
NFI	>0.90	0.926
RMSEA	<0.08	0.061

TABLE 5 Mediation effect.

	Beta-value	Std. Err.	t-value	Decision
CS → PBMAA	0.428	0.094	4.540	Accepted
CPE → PBMAA	0.073	0.015	4.893	Accepted
CPE → CS	0.463	0.124	3.734	Accepted
ENAT → PBMAA	0.372	0.048	7.702	Accepted
ENC → PBMAA	0.165	0.032	5.156	Accepted
ENC → ENAT	0.375	0.074	5.061	Accepted

PBMAA, Plant-based meat alternatives acceptance; CPE, Consumer perception; ENC, Environmental concerns; AAA, Accessibility and availability; CS, Consumer satisfaction; ENAT, Environmental attitude.

the bootstrapping sample data and imported it into MS Excel. In this process, we calculated the standard deviation to derive the t-values for the indirect paths. The t-value for the indirect path (CPE → CS → PBMAA) is 3.049 (indirect effect/standard deviation = 0.198/0.065), with a value of $p < 0.01$, supporting the conclusion that CS indeed mediates the relationship between CPE and PBMAA. Similarly, the t-value for the indirect path (ENC → ENAT → PBMAA) is 4.354 (=0.139/0.032), with a value of $p < 0.01$, signifying the meaningful inclusion of ENAT as a mediator between ENC and PBMAA.

Determining the strength of mediation holds significance in our analysis. We use the variance accounted for (VAF) method, which Hair et al. (2012) advise, to assess this. Based on Table 6, the influence of CS can account for 56.436% (VAF = indirect effect/total effect * 100) of the effect of CPE on PBMAA. Given that the VAF surpasses 20% and is less than 80%, it is concluded that CS serves as a partial mediator in this scenario. Furthermore, Table 6 also shows that 45.78% of the effect of ENC on PBMAA is accounted for by ENAT. With the VAF value within the range of 20 to 80%, it indicates that CS partially mediates the relationship between ENC and PBMAA.

5 Discussion

In the pursuit of sustainable diets, understanding consumer choices in the plant-based meat revolution holds significant importance. As society progresses toward a greater emphasis on environmentally sustainable food choices, it becomes evident that consumers significantly influence the transformation toward sustainable food systems. Through an in-depth exploration of the determinants that drive consumer acceptance of PBMA, we acquire significant insights into how to promote and encourage sustainable dietary choices on a broader scale.

The consumer perception has crucial role in influencing the acceptance of PBMA. The way in which consumers perceive these alternatives has a direct impact on their willingness to incorporate them into their diets. Therefore, findings reveals that the consumers perceive PBMA as delicious, high-quality, and satisfying substitutes for traditional meat, they are more likely to adopt them. Thus, the positive perceptions regarding taste and quality play and important role in breaking down initial resistance to trying PBMA as sustainable diets. It is widely recognized among marketers that the manner in which customers perceive the characteristics of an invention can have a significant impact on its rate of acceptance (Pan and Fesenmaier, 2000; Christou and Kassianidis, 2002). Previous studies have identified a notable barrier in the acceptance of PBMA diets among individuals who consume meat, which centers on their perception of substandard taste (Hoek et al., 2011; Pohjolainen et al., 2015; Bryant, 2019). There is a prevailing view among individuals that meat-based goods possess a more desirable taste in comparison to PBMA. This perception remains consistent even in the situation where consumers are provided with evidence indicating that all products have a similar taste (Van Loo et al., 2020; Michel et al., 2021). In spite of subjective taste preferences, individuals who regularly consume meat often perceive plant-based diets as comparatively less satisfying and nutritionally complete in comparison to meals that include meat (Kildal and Syse, 2017; Michel et al., 2021).

The findings of the study also revealed that promotional techniques have a significant influence on the adoption and acceptability of PBMA. There are various promotion strategies that can affect the acceptability of PBMA and transition toward sustainable food systems. The strategies include measures such as enhancing the availability of PBMA in restaurants and fast-food chains, adopting discounts and promotional offers on PBMA products, carrying out educational campaigns to emphasize the benefits of PBMA, and employing effective packaging and labeling strategies that will positively affect consumer behavior. These promotional strategies align with consumer preferences and their decision-making processes, and they also reflect their level of awareness and perception of credibility. According to study findings, it can be inferred that an effectively designed promotional strategy holds the capacity to considerably accelerate the adoption and uptake of PBMAA. Consequently, this can play a pivotal role in fostering the acceptance of more environmentally sustainable dietary choices on a broader scale. The utilization of price promotion as a marketing tactic has been extensively employed to enhance consumer usage experiences and attract new customers during the initial phase of product introduction (Zhang et al., 2020). This approach involves a temporary reduction in the unit price of a certain product. Price markdown is a prevalent strategy employed in the field of price promotion. The enactment of nutrition labeling on food products has been a major strategy for promoting healthy dietary choices (Cowburn and Stockley, 2005). According to Feunekes et al., 2008, required nutrition labels serve as a health education intervention that has a wide scope of influence. These labels are prominently displayed at the moment of purchase and also during food preparation and consumption. Previous studies have demonstrated that the utilization of simplified labels has a positive impact on enhancing the precision of individuals' nutrition assessments of unhealthy items (Finke, 2000). Nutrition labels are commonly perceived as a reliable and authoritative means of obtaining information, and a considerable portion of

TABLE 6 Mediation analysis.

Path	Coefficient	Indirect effect	Sta. Dev.	Total effect	VAF (%)	t-value
CS → PBMAA	0.428	0.428*0.463 = 0.198	0.065	0.152 + 0.198 = 0.351	(0.198/0.351) *100 = 56.436	3.049
CPE → PBMAA	0.153					
CPE → CS	0.463					
ENAT → PBMAA	0.372	0.372*0.375 = 0.139	0.032	0.165 + 0.139 = 0.304	(0.139/0.304) *100 = 45.780	4.354
ENC → PBMAA	0.165					
ENC → ENAT	0.375					

PBMAA, Plant-based meat alternatives acceptance; CPE, Consumer perception; ENC, Environmental concerns; CS, Consumer satisfaction; ENAT, Environmental attitude.

consumers depend on them to guide their decision-making process when purchasing food items. The existing body of evidence consistently indicates a favorable correlation between the implementation of successful promotional methods and the adoption of healthy food patterns (Campos et al., 2011).

The perception of a person's health significantly impacts the acceptance of PBMA. The inclination toward PBMAA among individuals who prioritize their health is substantiated by its perceived positive impact on health, which encompasses lower levels of saturated fats and cholesterol, alongside a rich content of essential nutrients. The attractiveness of PBMAA is strengthened by the perceptions that it contributes to general health, aids in weight management, is easily digestible, and has a good impact on heart health. The importance of acknowledging PBMAA as a preferable alternative for mitigating foodborne illnesses cannot be overstated, particularly for customers who prioritize safety. The general perception of PBMA as a more sustainable diet alternative, as shown by the scale, highlights its potential for widespread acceptance, especially among individuals who prioritize their health and nutritional needs in their eating habits. Over the past five decades, there has been a growing emphasis on the significance of health in relation to consumers' selection of food. Studies examining consumer perceptions of food quality reveal that both health and sensory factors hold approximately similar significance (Grunert, 2006). According to Bucher et al. (2015), a research investigation was conducted to examine the perception of the nutritional value of soft drinks. The study revealed that the presence of fruit in soft drinks was positively correlated with the perception of healthiness, however higher levels of sugar concentration and fat contents were negatively linked with healthiness perception.

The acceptance of PBMA is notably influenced by environmental concern. Consumers conscientiously take into account the environmental consequences of their dietary decisions, which encompasses the contribution of PBMA in transition toward sustainable food systems. Moreover, consumers are swayed by overarching ENC, such as the greenhouse gas emissions stemming from the food business. The users' inclination to actively seek information regarding the environmental advantages of PBMAA and their willingness to pay a premium for sustainable alternatives highlights the significance of sustainability. The conviction on the positive impact of PBMA on the preservation of natural resources serves to strengthen their attractiveness. Furthermore, it is evident that consumers exhibit a proactive approach in their quest of ecologically sustainable products when engaging in grocery shopping, so emphasizing their dedication to making eco-conscious decisions.

In conclusion, the consideration for the environment significantly influences the acceptance and desire for PBMA, particularly among persons who prioritize sustainability and choose to match their dietary choices with eco-conscious behaviors. The literature suggests that there is a connection between ENC and consumers' pro-environmental actions aimed at protecting the environment (Cruz and Manata, 2020; Molinillo et al., 2020; Kumar et al., 2021). Additionally, it has been observed that consumers are motivated to choose products that incorporate natural elements, as indicated by their preference for natural content (Molinillo et al., 2020). The findings of our study align with the research conducted by Cheung and To (2019), which demonstrated that individuals who are environmentally concerned tend to engage in natural consumption habits as a result of their ENC. It is anticipated that consumers who possess an increased consciousness of environmental concern will exhibit a preference for products that are environmentally friendly (Essoussi and Zahaf, 2008). According to the findings of Lin and Huang (2012), there exists a positive relationship between individuals' level of environmental concern and their inclination toward selecting and adopting green products.

The acceptance and preference for PBMA are greatly influenced by the factors of AAA. The influence of PBMA's availability in local grocery stores on purchase decisions highlights the significance of retail accessibility. The presence of plant-based menu options in restaurants serves as a catalyst for the increased selection of PBMA, when individuals choose to dine out. The convenient availability of PBMA in local retail establishments is indicative of its easy accessibility. The deliberate pursuit of plant-based eating alternatives and their favorable consequences in preferred restaurants highlights the significance of accessibility in influencing individual preferences. The criteria associated with AAA play a critical role in determining the acceptance of PBMA, hence emphasizing the need for their widespread availability. There is an increasing body of evidence suggesting that the availability of healthier food options plays a significant role in influencing individuals' eating choices (Delva et al., 2007). The interconnection between food accessibility, availability, and choice is undeniable. The purchasing options for consumers are limited to the products that are both accessible and available to them. Consequently, regardless of an individual's level of nutrition knowledge or income, the selection of food is ultimately determined by the availability of food items. The significance of "food selection" outweighs that of "food choice" due to the limited options available to consumers, who can only select from the products offered in the accessible stores (Furey et al., 2001; Bustillos et al., 2009).

The mediating role of consumer satisfaction in the relationship between consumer perception and acceptance of PBMA is highly significant. Consumer perceptions about PBMA have a significant effect on consumer attitudes and choices toward PBMA. Positive perceptions regarding taste, nutrition, and sustainability enhance the likelihood of PBMA's acceptance (Hoek et al., 2011). Simultaneously, consumer satisfaction plays a pivotal role because it is rooted in post-purchase experiences (Oliver, 1980) and alignment with expectations. Therefore, when PBMA meets or exceeds the expectations of consumers, it fosters their satisfaction and ultimately reinforces the acceptance process. These findings highlight the significant impact of consumer perception and their satisfaction in driving the acceptance of PBMA, with extensive implications for sustainable diets and the food industry.

The research has identified the noteworthy mediation function of environmental attitude in the relationship between consumers' ENC and their acceptance of PBMA. The significance of one's environmental attitude, including personal beliefs and concepts related to ecological sustainability, is pivotal in influencing one's desire for accepting PBMA. Consumers that possess a favorable environmental attitude are more likely to choose PBMA owing to their less ecological impact as compared to traditional meat products. Furthermore, the acceptability of PBMA is influenced by environmental concern, which is rooted in an increased knowledge of pressing environmental issues and a personal dedication to minimizing one's carbon footprint. As the level of environmental consciousness among individuals increases, there is a greater propensity for them to select sustainable dietary options such as PBMA. The study conducted by Sadiq et al. (2020) has demonstrated that dietary habits, which are impacted by environmental considerations, have the potential to contribute to climate change (Carlsson-Kanyama and González, 2009). The prior research by De Boer et al. (2014) emphasized the importance of changing Western meat consumption patterns for better health outcomes and address environmental issues (Sarigöllü, 2009; Pavalache-Ilie and Cazan, 2018). Similarly, studies have reported that individuals with higher ENC are more likely to develop positive environmental attitudes. This positive attitude toward environment can influence their food choices (Verain et al., 2015). Collectively, these characteristics underscore the crucial significance of environmental attitudes and concerns in facilitating the acceptance of PBMA. This alignment of consumer behavior with eco-conscious dietary choices and the promotion of sustainable food practices is emphasized.

Although this study presents valuable insights for policymakers and meat consumers, it is not without limitations. First, sampling bias may arise due to an online data collection method, which can be a complex task to address when attempting to obtain a representative sample of the Chinese population owing to its extensive and heterogeneous demographic composition. Second, it is important to consider the potential impact of the social desirability bias on respondents' answers. This tendency may lead individuals to submit responses that they perceive as socially acceptable, rather than expressing their genuine beliefs. Consequently, this could result in overestimation of the reported levels of acceptance of PBMA. Finally, the ever-changing nature of consumer preferences and swiftly growing culinary trends in China may result in the data soon becoming outdated, thus restricting its long-term applicability of study

findings. The future studies may conduct comprehensive face to face interviews to gain a deeper understanding of the cultural and contextual elements that influence the reception of PBMA in different areas of China.

6 Conclusions and policy recommendations

In today's pursuit of sustainable dietary choices and a sustainable food system, comprehending the consumer behaviors and preferences in the context of the plant-based meat revolution is of paramount importance. The transformation toward sustainable food systems toward more environmentally conscious and sustainable practices significantly depends on the consumers behavior and their dietary choices. Hence, a comprehensive exploration of the factors influencing consumer acceptance of PBMA not only elucidates the factors driving this transformation but also offers valuable insights into how we can promote and encourage sustainable dietary choices on a broader spectrum.

This study highlights the significant impact of consumer perceptions, particularly regarding taste, texture, nutritional value, and prices, on the acceptance of PBMA. It is imperative to address the problems associated with taste and nutritional value in comparison to conventional meat. Effective promotional strategies significantly influence the acceptance of PBMA. The convenient availability and accessibility of PBMA play a crucial role in shaping individual dietary cultures. Moreover, this study sheds light on the importance of health consciousness and environmental concern in forming consumer preferences for PBMA, highlighting the role of HPE and sustainability in dietary decision-making. Additionally, the mediating role of consumer satisfaction and connecting consumer perception reinforces PBMA acceptance. Moreover, the study underscores the mediating role of environmental attitude, which establishes a connection between ENC and the acceptance of PBMA, underscoring the importance of sustainable dietary choices. Therefore, comprehending these aspects is essential for promoting sustainable dietary choices and transforming the food industry to align with evolving consumer preferences and ecological concerns.

In order to facilitate the widespread acceptance of PBMA and encourage sustainable dietary choices, a multifaceted approach is essential. Food manufacturers should emphasize improving the sensory attributes and nutritional value of PBMA while using effective promotion strategies that highlight aspects including taste, texture, health benefits, and sustainability. Widespread availability of plant-based meat alternatives in fast-food chains, restaurants, and grocery stores, along with clear and comprehensive nutrition labeling, can increase accessibility and enable individuals to make well-informed decisions. It is recommended that educational campaigns be initiated, particularly those promoting the environmental benefits of PBMA, in order to reshape consumer perceptions. The acceptance of PBMA will be driven collaboratively by collaboration among industry stakeholders, environmental organizations, and governments, as well as through consumer engagement and research and development activities. In essence, this collaborative effort has the potential to enhance the sustainability of the food system by aligning consumer behavior with environmentally conscious decisions and transforming

the food industry to accommodate evolving consumer behavior and ENC.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Wuhan Business University, Wuhan, China. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SE: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. SQ: Conceptualization, Formal analysis, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. LW: Data curation, Formal analysis, Methodology, Writing – review & editing. MD: Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2023.1315448/full#supplementary-material>

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