



Understanding the consumption of plant-based meat alternatives and the role of health-related aspects. A study of the Italian market

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ABSTRACT

One possible solution to address some of the current health and environmental challenges we are facing is to choose plant-based meat alternatives (PBMAs). However, from the literature, the role of PBMA products in the consumer's diet and whether they are a substitute for red meat consumption or if they only represent an enrichment function is not clear. Moreover, little is known about how health-related aspects affect consumer choices. This study tries to understand the role of PBMAs in consumption habits and the effects of health-related aspects in PBMA consumption. The results show that PBMA consumption occurs in substitution to red meat, and it is associated mainly with healthy and sustainable habits, such as organic food consumption, and socio-demographic factors like higher income and gender. The study findings may help marketers define product value propositions in line with consumers' perceptions.

1. Introduction

The increased prevalence of red meat consumption in consumers' diets raises concerns about food safety, nutrition, and sustainability, especially considering an estimated global population of 10 billion by 2050 (FAO, 2018; Hielkema and Lund, 2021; Hu et al., 2019; Migliore et al., 2015). For example, intensive agricultural production (e.g., from cattle) has a high impact on GHG emissions, water and soil usage and biodiversity, especially related to meat production (FAO, 2018; Gerber et al., 2013). The United Nations reports how the livestock sector generates one-seventh of global GHG emissions and consumes about one-third of all fresh water on earth, which has negative environmental impacts (UN Climate Change, 2021). The negative impact of meat production also affects animal welfare (Aiking et al., 2006). Reducing red meat consumption is also recommended by several nations' dietary guidelines because diets high in red meat are responsible for a wide range of health consequences (FAO, 2018; Willett et al., 2019; World Health Organization, 2015). For this reason, the World Health Organization (WHO) has classified red meat as a probable human carcinogen and facilitator of the development of several diseases, including

cardiovascular disease, obesity, and type 2 diabetes mellitus (Hu et al., 2019; Willett et al., 2019; Wolk, 2017; WHO, 2015; Rouhani et al., 2014).

Although the consumption of meat provides high-quality protein and a variety of other essential nutrients like iron, vitamins, and fat, which are difficult to obtain in adequate quantities from foods of plant origin, it has been observed that consumers' dietary habits are now changing in favour of plant-based meat alternatives (PBMAs) (Demartini et al., 2022; Godfray et al., 2018; Naghshi et al., 2020; Santo et al., 2020; Willett et al., 2019). Though most consumers seemed unaware of the negative impact of meat production and consumption on the environment (Hartmann and Siegrist, 2017), some recent studies showed that consumers associate the production of PBMAs with a positive impact on the environment and potential health benefits (Hu et al., 2019; Michel et al., 2021; Perez-Cueto et al., 2022; Santo et al., 2020). Due to the growing number of consumers around the world who will substitute protein from animal sources with plant-based proteins, it is estimated that the global market of plant-based substitutes will reach \$ 85 billion (USD) by 2030 (Gordon et al., 2019). To benefit from the transition to a plant-based dietary model, companies are increasingly developing innovations to

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provide consumers with a wide variety of plant-based meat alternatives (PBMA), whose sensory profiles are very close to those of traditional meat (Curtain and Grafenauer, 2019; Harnack et al., 2021; Kołodziejczak et al., 2022; Westling et al., 2022). However, the transition to an increased use of foodstuffs based on plant-protein alternatives requires more input in terms of water, pesticides and fertilisers to produce the same amount of proteins provided by meat (Marlow et al., 2009). Moreover, the more recent PBMA (e.g., the "Beyond Meat" burger), which are often labelled using "meat-sounding" names, are expected to attract more consumers than those who typically purchase vegan or vegetarian foods (Demartini et al., 2022; Hu et al., 2019). It is also important to note that consumers of meat prefer meat alternatives that resemble meat, while those who prefer consuming less or no meat favour meat alternatives that do not resemble meat (Hoek et al., 2011).

In this context, the factors behind this market trend are not clear enough, producing in some cases conflicting results. While it seems clear from the literature that ethical reasons are the primary motivators of consumers' choices towards PBMA (Boukid, 2021; Michel et al., 2021), more has to be done to explore the health-related motivations underpinning their consumption choices (Hu et al., 2019). Several studies revealed that PBMA are chosen by those consumers with high health awareness and interest in their state of health, as they are perceived as healthier than traditional meat (Szenderák et al., 2022; Florack et al., 2021; Martin et al., 2021; Sucapane et al., 2021; Fehér et al., 2020; Hu et al., 2019). However, in many cases, there is not much evidence that similar alternatives may bring significant health benefits (Hu et al., 2019). Other studies showed that health-related aspects could represent a motivational barrier in consumers' decision-making toward PBMA products (Jahn et al., 2021; Tso et al., 2021; McBey et al., 2019). Often, they are perceived as less healthy and natural than meat since they are "ultra-processed" and supplemented with various artificial ingredients (Bryant, 2022; Jahn et al., 2021). For example, vegetable burgers are often obtained by mixing refined grains and have a high sugar content, allegedly reducing their nutritional quality.

Therefore, a comprehensive view of the role of health-related aspects in consumers' decision-making toward PBMA products still needs to be addressed. In other words, it would be interesting to clarify if PBMA can be considered a valid substitute for red meat or represent another food group that can complement consumers' diets, as hypothesised in other studies (Michel et al., 2021; Szejda et al., 2021). Therefore, the current study has two objectives: 1) identify the role of PBMA products in consumers' diets; 2) understand how factors such as sociodemographic variables, consumption habits, and health-related aspects affect PBMA consumption. A stratified sample of 1142 Italian consumers responsible for household food purchases has been used to reach this objective. This study aims to add knowledge on the PBMA products market and support firms' marketing strategies in defining product value propositions in line with consumer perceptions.

2. Factors potentially influencing PBMA consumption

According to the literature, the main reasons to choose PBMA products seem to be associated with ethical aspects, animal welfare and environmental issues (Hopwood et al., 2020; Hwang et al., 2020). However, there is still contrasting evidence on the role of health-related aspects and consumer sociodemographic and psychographic characteristics on PBMA consumption.

2.1. Health-related factors

On one hand, some studies have highlighted that PBMA are chosen not only by people with health problems but also by a growing number of consumers who share an interest in their state of health (Szenderák et al., 2022; Michel et al., 2021; Sucapane et al., 2021). A study carried out in the United Kingdom (UK) and Ireland, Beacom et al. (2021) showed that healthiness represents the most critical attribute in

consumer decision-making related to PBMA. Similarly, another study found that consumer preference towards PBMA is mainly linked to consumer awareness of the health consequences of unhealthy food choices (Florack et al., 2021). The importance of health as a primary driver for substituting meat with PBMA is also highlighted in a recent study by Michel et al. (2021) conducted in Germany, France, and the UK. According to Michel et al. (2021), consumers from those countries introduced PBMA in their diet to enrich it and substitute meat for health-related reasons. Also, Szejda et al. (2021), analysing a South-African representative sample, revealed that PBMA products are perceived as healthy. However, the same study showed that the consumption of PBMA is mainly related to perceived potential health benefits and enriching the daily diet, rather than as a meat-substitute (Szejda et al., 2021).

Conversely, some studies have highlighted that health-related aspects represent a motivational barrier in PBMA consumption (Embling et al., 2022; Jahn et al., 2021). Consumers appear unwilling to buy PBMA as they are perceived as unnatural or ultra-processed (Circus and Robison, 2019; McBey et al., 2019). According to Possidónio et al. (2021), the perception of the wholesomeness of PBMA worsens according to the degree of processing to which these products are subjected. The higher the degree of transformation consumers perceive in PBMA products, the lower the perception of their naturalness (Varela et al., 2022, 2022de Vlieger et al., 2017). Another aspect that increases the unnatural image of PBMA among consumers is that they are often enriched with calcium, iron, vitamin B12, and other elements to increase their nutritional value (Kołodziejczak et al., 2022). Alternatively, more often they are perceived as unhealthy due to their high salt content to enhance their flavour, making meat preferable as a source of protein and essential nutrients (Szenderák et al., 2022; Harnack et al., 2021). If, on the one hand, this artificial enrichment discourages consumers from buying PBMA, on the other hand, their lack of essential nutrients could represent another barrier in the decision-making process. Corrin and Papadopoulou (2017) show that consumers' acceptance of PBMA is inversely proportional to the perception that meat is a major source of essential nutrients for their life. Indeed, most consumers believe that animal meat contains important nutrients that cannot be replaced, which in turn discourages PBMA consumption (Kemper and White, 2021). This is demonstrated by a recent study by Estell et al. (2021) in which PBMA are considered products without iron or vitamin B12; therefore, they do not bring any health benefits. Furthermore, some consumers consider these products risky for their health (Verbeke, 2015) and believe they might cause possible adverse long-term health effects (Gallen et al., 2019).

Therefore, it is of fundamental importance for the food industry to understand what role health-related aspects play in the consumption of PBMA products, since this knowledge may help in devising the best communication strategies to develop the market for these meat alternatives.

2.2. Sociodemographic and other factors

Other authors have highlighted that PBMA consumption is also affected by the sociocultural context in which consumers live (Onwezen et al., 2019, 2021). A study by Onwezen et al. (2019) confirmed that consumers are affected by the opinions of others in choosing PBMA. Indeed, according to previous studies (Figueira et al., 2019; Sogari et al., 2016), consumers are discouraged from trying PBMA if their friends or family have a negative opinion of them. Conversely, Jensen and Lieberoth (2019) showed that consumers are more willing to try new alternative proteins if other acquaintances say they have tasted and consumed these products. This is because as more people experience new alternative products, the more they are perceived as more socially acceptable (Schäufele et al., 2019).

Regarding sociodemographic factors, some studies report PBMA consumption as being higher among women, young consumers, and

highly educated people (Onwezen et al., 2021), as they are more likely to eat a predominantly or exclusively vegetarian diet (Gómez-Luciano et al., 2019; Rothgerber, 2013; Janda and Trocchia, 2001), recognizing it as healthier and sustainable (Cordts et al., 2014; Guenther et al., 2005). However, other studies did not confirm any sociodemographic segmentation in PBMA consumption (Szejda et al., 2021; Hwang et al., 2020).

3. Methodology

3.1. Data collection

A professional marketing agency collected data through an online survey conducted in Italy in October 2021. Before data collection, a nationally stratified sample was selected by age, frequency of red meat consumption and region. Respondents were at least 18 years old and responsible (or co-responsible) for household food shopping. The average time to complete the questionnaire was 17 min.

The survey was divided into three sections. In the first section, the question 'In the past six months, on average, how often have you consumed PBMA (e.g., burgers, legume patties, soy-based stew, etc.)?' had seven response options ranging from 'every day' to 'never'. Those who selected the latter option were excluded from the database. Questions about respondents' purchasing habits were also formulated in this section, including overall food expenditure and the percentage of spending on local and organic products (from 0% to 100%). Food expenditure shares were included, given that, according to the literature, people following a sustainable and ethical diet are more likely to accept PBMA products (de Boer et al., 2013; Grasso et al., 2019; Vita et al., 2019). Participants were also asked to report their frequency of red meat consumption on a 7-point Likert scale - from never to every day.

The second section of the questionnaire was aimed at gathering information on health-related aspects associated with PBMA products. Specifically, information was gathered on consumers' interest in their health status, their risk propensity, and the perception of their body weight. The 8-item scale developed by Roininen et al. (1999), called General Health Interest (GHI), was used to obtain information on consumers' general interest in health. Respondents' degree of agreement for each scale item was identified by scoring on a 7-point Likert scale ranging from 'Totally disagree' to 'Totally agree'. The literature suggests that high values on this scale are associated with healthier food choices, while lower values are synonymous with a less balanced diet (Roininen et al., 1999).

Risk propensity, defined as the tendency to take risks in everyday life, was investigated with the following item: 'How do you see yourself: are you generally a person who is fully prepared to take risks, or do you try to avoid taking risks?' (Dohmen et al., 2011). Consumers could answer using a 7-point Likert scale from 'Not at all willing' to 'Completely willing'. The risk propensity item was chosen to measure acceptance/avoidance of risks in choosing PBMA products (Verbeke, 2015). Moreover, consumers were asked to indicate on a 7-item scale how they perceive their body weight, from 'very bad' to 'very good' (Cordts et al., 2014). Weight control is another main reason to remove (totally or gradually) meat from consumers' diets, substituting it with plant-based proteins (Bryant, 2019). Consumers perceive that PBMA favours muscle synthesis and weight loss thanks to their low-fat content and nutritional profile, decreasing the risks related to the occurrence of several diseases (Bryant, 2022).

Among other psychographic variables, a two-item scale (Berndsen and van der Pligt, 2004) investigating perceived social pressure and motivation to comply was used to study perceived pressure from social norms. As highlighted by the literature, social norms play a crucial role in choosing PBMA products; consumers are more willing to try new PBMA products if other acquaintances have a favourable opinion of them (Jensen and Lieberoth, 2019).

Finally, in the third section sociodemographic characteristics such as gender, residence, age, education level (measured in six categories: elementary school leaving certificate, junior high school leaving certificate, diploma, bachelor's degree, master's degree, doctorate), and household monthly income (measured in four categories: 'With my household income I have a lot of difficulty coping with all the financial expenses that come up during the month', 'With my household income I have some difficulty coping with all the financial expenses that come up during the month', 'With my household income I have no difficulty coping with all the financial expenses that come up during the month', 'With my household income I manage to put some savings aside') were investigated.

3.2. Data analysis

The acquired data were processed using STATA 16 statistical software. Initially, descriptive analyses were conducted on the sample variables to delineate consumers' profile and their purchasing habits. Next, the internal consistency of the scales, their mean value, and the correlation between the various items were calculated. Finally, an Ordered Logit Regression was implemented to test the drivers of PBMA consumption. This model is a generalisation of Logit Regression and accounts for the ordinal nature of the dependent variable (Greene, 2017; Migliore et al., 2015). In this case, the dependent variable was the frequency of PBMA consumption in the past six months.

The model is based on the cumulative probabilities of the response variable. Specifically, the logit of each cumulative probability is assumed to be a linear function of the covariates with constant regression coefficients across response categories (Cameron and Trivedi, 2015). The odds ratios are determined by measuring the changes in the probability of the dependent variable following a unit change in the explanatory variable, making explicit the weight of each independent variable on the dependent variable in the regression.

4. Results

4.1. Sample characteristics

Of 1142 survey respondents, 268 (23.5%) declared they do not consume any PBMA products and therefore were not considered in this study. Of the 874 respondents left in the analysis, the majority (62%) have a middle/low educational qualification. Almost half of the respondents (45%) declare a medium monthly household income, while a third of respondents have a low income. Regarding respondents' area of residence, most (46%) live in medium-sized cities, followed by those living in large cities (42%) (Table 1).

For the purpose of the econometric analysis, the variables 'Monthly income' and 'Education' were recoded into binary variables (i.e., 0 = Low income - difficulties; 1 = Higher income - no difficulties; 0 = Not graduated; 1 = Graduate).

The purchasing habits of the sample are reported in Table 2. The survey revealed that more than half of the sample (53%) regularly consume PBMA products (from every day to at least once a week). About a third of the sample (35%) stated that they rarely consume PBMA and 12% of the sample consume PBMA approximately once every 15 days. Over 83% of the sample consumes red meat regularly, at least once a week.

Only a small portion of the sample never consumes organic or local foods (5.3% and 1.3% respectively). Organic food expenditure on total food expenditure is between 20% and 50% for over a third of the sample. While for almost half of the sample, local food expenditure is between 20% and 50% of total food expenditure.

4.2. Descriptive analysis

As regards psychographic factors, the internal consistency of the GHI

Table 1
Sociodemographic characteristics.

Variables	Description	Variables structure	Sample (N = 874)
Gender	Gender	Female	345 (39.47%)
		Male	529 (60.53%)
Age	Age in years	Mean \pm S.D.	43.59 \pm 12.15
Education	Level of education	Not graduated	542 (62.01%)
		Graduate	332 (37.99%)
Monthly income	Expenditure difficulties/Income	Low (difficulties)	472 (54.01%)
		High (no difficulties)	402 (45.99%)
Residence	Size of the city of residence, considering the population size	<5,000	98 (11.21%)
		5,000–50,000	405 (46.34%)
		>50,000	371 (42.45%)

Table 2
Sample purchasing habits.

Variables	Description	Categories	Sample (N = 874)		
PBMA consumption frequency	Frequency of consumption of plant-based meat alternatives	Rarely	305 (34.90%)		
		1 time every 15 days	103 (11.78%)		
		1 time per week	274 (31.35%)		
		2-3 times a week	176 (20.14%)		
		4-5 times a week	14 (1.60%)		
		Daily	2 (0.23%)		
		Red meat consumption frequency	Frequency of consumption of red meat	Never	0 (0%)
				Rarely	49 (5.61%)
1 time every 15 days	90 (10.30%)				
1 time per week	337 (38.56%)				
2-3 times a week	332 (37.99%)				
4-5 times a week	57 (6.52%)				
Organic food purchase	Incidence of organic products on total food expenditure			0%	46 (5.27%)
				<20%	433 (49.54%)
		20 - 50%	320 (36.61%)		
		50 - 75%	69 (7.89%)		
		>75%	6 (0.69%)		
Local food purchase	Incidence of local products on total food expenditure	0%	11 (1.26%)		
		<20%	243 (27.80%)		
		20 - 50%	432 (49.43%)		
		50 - 75%	157 (17.96%)		
		>75%	31 (3.55%)		

scale has been checked by calculating Cronbach's alpha, which was found to be always greater than 0.77, showing the high consistency of respondents' answers. For each psychographic variable, the mean value was determined (Table 3) and used in the subsequent regression.

4.3. Regression model

An Ordered Logistic Regression model was implemented to understand the role of PBMA products in consumers' diets and how health-related aspects affect PBMA consumption (Cameron and Trivedi, 2015). The regression results show that multiple factors influence PBMA consumption frequency (Table 4). Among the sociodemographic variables, high monthly income and being female significantly and positively influence the likelihood of PBMA consumption ($p < .010$, and $p < .050$, respectively). In contrast, education level, residence area, and age do not significantly affect PBMA consumption. The consumption of organic products significantly increases the probability of consuming PBMA more frequently. In other words, the frequency of organic product consumption seems to play the most important role in PBMA consumption because it increases the likelihood of eating these product typologies 1.8 times ($p < .000$).

A negative relation was found between the frequency of red meat consumption and the frequency of PBMA consumption (OR = 0.817, $p < .050$). In other words, a decrease in the frequency of red meat consumption corresponds to an increase in the probability of PBMA consumption. Regarding the factors related to health aspects, only the GHI affects the likelihood of increasing PBMA consumption (1.07 times), while both body weight and risk propensity do not have a significant influence on the consumers' likelihood of consuming PBMA.

5. Discussions

Survey results show a surprisingly high percentage of respondents declaring PBMA consumption compared to previous studies (de Boer et al., 2013; Hoek et al., 2011), indicating a potentially increasing market in Italy. In USA, Zhao et al. (2022) report that market demand for PBMA quadrupled from 2017 to 2022, though overall demand is still low compared to meat.

Regression results highlighted that the overall interest in one's health positively influences the choice to eat PBMA. The literature shows that health awareness and attitudes toward healthy food positively affect the choice to buy PBMA (Szenderák et al., 2022; Onwezen et al., 2021). Consumers consider healthiness a key factor for PBMA acceptance and are willing to consume these products (Florack et al., 2021; Michel et al., 2021; Szejda et al., 2021). This is in line with a previous study by Beacom et al. (2021) which showed consumers perceive PBMA as healthier than meat, despite tasting worse. This is because PBMA are often seen as a tool to prevent diseases, offering the possibility of achieving well-being through food choices (Fehér et al., 2020). However, unlike other studies (Gallen et al., 2019; Verbeke,

Table 3
Psychographic factors.

Variables	Description	Mean \pm S.D.
Body weight	Perception of own body weight	4.90 \pm 1.83
Social norms	Moral perception that consumption of PBMA is expected by people important for the life of consumers (family, peers and friends)	4.19 \pm 1.53
Risk propensity	Tendency to take risk every day	3.23 \pm 1.47
GHI	General interest in one's own health	4.72 \pm 0.95

The explanatory variables used in the model are little or not correlated (Appendix A).

Table 4
Factors affecting PBMA consumption frequency – Odds Ratio.

Variables	Odds Ratio	Std. Err.	Z	P> z
Female (gender)	1.298	0.102	-1.97	0.048
Age	0.996	0.005	-0.60	0.514
Graduate (education)	0.859	0.115	-0.98	0.257
High income	1.316	0.168	2.64	0.031
Residence (5,000–50,000)	0.914	0.122	-0.62	0.503
Residence (>50,000)	0.765	0.162	-1.25	0.206
Organic cons. freq.	1.820	0.170	6.34	0.000
Local cons. freq.	1.153	0.099	1.63	0.097
Red meat cons. freq.	0.817	0.068	-2.46	0.015
Body weight	0.951	0.037	-1.38	0.194
Social norms	1.111	0.059	1.98	0.046
Risk propensity	1.065	0.046	1.38	0.146
GHI	1.082	0.038	2.25	0.024

Notes: Number of obs. = 874; LR $\chi^2(11) = 71.16$; Prob > $\chi^2 = 0.000$; Pseudo R² = 0.0288.

2015), consumer awareness of their body weight and the tendency to take daily risks does not significantly affect the choice to consume alternatives to meat products. This highlights that consumers do not decide to buy PBMA to reduce or control their weight, contrary to previous literature (Banovic and Otterbring, 2021).

Being an organic consumer greatly influences the probability of increasing the purchase of PBMA, confirming that this category of products is mainly chosen by those consumers that show healthy and sustainable consumption habits and lifestyles (Testa et al., 2019, 2020; Kushwah et al., 2019; Migliore et al., 2015). Organic consumers are more likely to buy PBMA since a plant-based diet is often associated with a healthy and sustainable diet (Sucapane et al., 2021; Schiano et al., 2020; Migliore et al., 2018). This could have interesting implications for PBMA firms, as organic consumers could represent the main target for PBMA products. Organic certification for these products should be considered to meet these consumer needs, though Prada et al. (2017) report that consumers question the healthiness of highly processed organic food products such as PBMA. Further research is needed to explore this topic.

Among other variables, only social norms significantly affect the probability of PBMA consumption, in agreement with other studies (Allen et al., 2018; Jahn et al., 2021; Onwezen et al., 2019).

Regarding sociodemographic variables, higher income increases the probability of purchasing PBMA; as in other studies, women and higher-income consumers are more likely to choose plant-based products (Szenderák et al., 2022; Onwezen et al., 2021; Bryant et al., 2019). The other variables – age, residence, and education – are not significant. Some studies report that women, young consumers and highly educated people usually choose PBMA (Onwezen et al., 2021), as they are more likely to eat a predominantly or exclusively vegetarian diet (Gómez-Luciano et al., 2019; Rothgerber, 2013; Janda and Trocchia, 2001), recognizing it as healthier and sustainable (Cordts et al., 2014; Guenther et al., 2005). However, other studies also found these variables not significant in explaining PBMA consumption (Szejda et al., 2021; Hwang et al., 2020).

6. Conclusions and limitations

This study sheds light on the role PBMA play in consumers' diets as a healthy meat substitute. The awareness of potential health benefits associated with PBMA influences the likelihood of their consumption. Furthermore, the likelihood of purchasing PBMA is associated with healthy and sustainable diets, such as organic food consumption. Therefore, organic certification is a relevant attribute for marketing PBMA, while organic consumers represent a significant market segment. Our findings could help marketers of PBMA products to reach a larger market share by adopting specific product lines, labels, or advertising campaigns related to the potential health benefits of PBMA

and their role in diet.

The results obtained may have empirical and policy implications.

First, this study adds additional knowledge about PBMA consumers and the factors affecting their choices, attempting to better understand the role of health-related aspects. In this regard, the representativeness of our sample allows us to provide significant additional empirical evidence on a topic with several conflicting results in the literature.

Second, from a policy perspective, our findings could support policymakers in designing measures to support healthier plant-based diets. In particular, PBMA choice is associated mainly with healthy and sustainable habits, such as organic food consumption. The results of this study may help policy makers to devise policies supporting PBMA as a tool for more sustainable food production and consumption according to the UN's 2030 Agenda goals.

However, the study presents some limitations. Results refer only to self-declared PBMA consumers. Factors influencing consumers to introduce PBMA to their diets were not investigated and is left to further studies. In addition, in this study, we mainly focus on the role that health-related aspects could have on consumers' decisions, considering the general interest in health, perception of body weight, and the tendency to take risks. Other potentially relevant factors, such as environmental concerns, animal welfare, sensorial perception, technophobia or neophobia were not included in this study. Finally, the study focuses on Italian consumers. Further studies should replicate the research in other countries to identify specific context-dependent results.

6.1. Implications for gastronomy

Additional knowledge of health-related aspects is an able tool to meet consumers' needs and interests and, therefore, to facilitate PBMA consumption. In particular, the gastronomy industry should develop its marketing strategies considering that consumers choose PBMA not only if they have a high general health interest but also for their sustainable consumption habits and the sociocultural context in which they live. In this context, our findings could help PBMA firms to reach a larger market share by adopting specific product lines, labels, or advertising campaigns so that consumers perceive the healthy characteristics of PBMA.

Agreement to publication

All authors read the final version of the present manuscript and declare that the results of the present work have not been submitted elsewhere or present conflict of interests. Also, authors agree to all publication policies of IJGFS.

Ethical statement

The experimental procedure was approved by the Ethics Committee of the University of Palermo (approval certificate no. 105/2022) in line with the principles of the Declaration of Helsinki.

Author contributions

Conceptualisation: G.R., G.M., R.T.; Methodology: M.G., G.R., R.T.; Validation: R.Z., G.S., E.C.D., F.S., S.M.; Formal analysis: G.R., G.S.; Data curation: G.R., E.C.D., F.S.; Writing-original draft preparation: G.R., R.T., S.M.; Writing-review and editing: G.M., R.Z.; Supervision: G.M.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix. Correlation analysis

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1)	1.000											
(2)	0.148	1.000										
(3)	-0.029	-0.160	1.000									
(4)	-0.018	0.066	-0.219	1.000								
(5)	-0.133	-0.022	-0.101	0.005	1.000							
(6)	-0.139	-0.074	0.078	-0.021	0.040	1.000						
(7)	0.233	-0.017	-0.010	0.005	-0.059	0.364	1.000					
(8)	-0.070	0.043	0.051	0.036	-0.082	-0.003	-0.062	1.000				
(9)	-0.058	-0.053	-0.035	0.008	0.029	0.028	0.051	-0.121	1.000			
(10)	0.016	-0.145	0.172	-0.099	-0.105	0.051	0.019	0.002	0.009	1.000		
(11)	-0.059	-0.071	-0.025	0.060	0.045	0.022	0.010	-0.087	0.201	0.021	1.000	
(12)	-0.000	-0.057	-0.023	0.083	-0.044	0.045	0.080	-0.070	0.125	0.039	0.152	1.000

(1): Gender, (2): Age, (3): Education, (4): Monthly income, (5): Residence, (6): Org. cons. freq, (7): Local cons. freq, (8): Red meat cons. freq, (9): Body weight, (10): Social norms, (11): Risk propensity, (12): GHI.

References

- Aiking, H., de Boer, J., Vereijken, J.M., 2006. Sustainable Protein Production and Consumption: Pigs or Peas? *Environment & Policy*, vol. 45. Springer. <https://doi.org/10.1007/1-4020-4842-4>.
- Allen, S., Goddard, E., Farmer, A., 2018. How knowledge, attitudes, and beliefs impact dairy anti-consumption. *Br. Food J.* 120, 2304–2316. <https://doi.org/10.1108/BJFJ-12-2017-0733>.
- Banovic, M., Otterbring, T., 2021. Athletic abs or big bellies: the impact of imagery, arousal levels, and health consciousness on consumers' attitudes towards plant-based protein products. *Food Qual. Prefer.* 87, 104067. <https://doi.org/10.1016/j.foodqual.2020.104067>.
- Beacom, E., Bogue, J., Repar, L., 2021. Market-oriented development of plant-based food and beverage products: a usage segmentation approach. *J. Food Prod. Market.* 27, 204–222. <https://doi.org/10.1080/10454446.2021.1955799>.
- Berndsen, M., van der Pligt, J., 2004. Ambivalence towards meat. *Appetite* 42, 71–78. [https://doi.org/10.1016/S0195-6663\(03\)00119-3](https://doi.org/10.1016/S0195-6663(03)00119-3).
- Boukid, F., 2021. Plant-based meat analogues: from niche to mainstream. *Eur. Food Res. Technol.* 247, 297–308. <https://doi.org/10.1007/s00217-020-03630-9>.
- Bryant, C.J., 2022. Plant-based animal product alternatives are healthier and more environmentally sustainable than animal products. *Future Foods* 6, 100174. <https://doi.org/10.1016/j.fufo.2022.100174>.
- Bryant, C.J., 2019. We can't keep meeting like this: attitudes towards vegetarian and vegan diets in the United Kingdom. *Sustainability* 11. <https://doi.org/10.3390/su11236844>.
- Bryant, C.J., Szejda, K., Parekh, N., Deshpande, V., Tse, B., 2019. A survey of consumer perceptions of plant-based and clean meat in the USA, India, and China. *Front. Sustain. Food Syst.* 3. <https://doi.org/10.3389/fsufs.2019.00011>.
- Cameron, C.C., Trivedi, P.K., 2015. *Microeconometrics, Methods and Applications*. Cambridge University Press, New York, United States.
- Circus, V.E., Robison, R., 2019. Exploring perceptions of sustainable proteins and meat attachment. *Br. Food J.* 121, 533–545. <https://doi.org/10.1108/BJFJ-01-2018-0025>.
- Cordts, A., Nitzko, S., Spiller, A., 2014. Consumer response to negative information on meat consumption in Germany. *Int. Food Agribus. Manag. Rev.* 17.
- Corrin, T., Papadopoulos, A., 2017. Understanding the attitudes and perceptions of vegetarian and plant-based diets to shape future health promotion programs. *Appetite* 109, 40–47. <https://doi.org/10.1016/j.appet.2016.11.018>.
- Curtain, F., Grafenauer, S., 2019. Plant-based meat substitutes in the flexitarian age: an audit of products on supermarket shelves. *Nutrients* 11, 1–14. <https://doi.org/10.3390/nu1112603>.
- de Boer, J., Schöslér, H., Boersema, J.J., 2013. Motivational differences in food orientation and the choice of snacks made from lentils, locusts, seaweed or "hybrid" meat. *Food Qual. Prefer.* 28, 32–35. <https://doi.org/10.1016/j.foodqual.2012.07.008>.
- de Vlieger, N.M., Collins, C., Bucher, T., 2017. What is a nutritious snack? Level of processing and macronutrient content influences young adults' perceptions. *Appetite* 114, 55–63. <https://doi.org/10.1016/j.appet.2017.03.021>.
- Demartini, E., Vecchiato, D., Finos, L., Mattavelli, S., Gaviglio, A., 2022. Would you buy vegan meatballs? The policy issues around vegan and meat-sounding labelling of plant-based meat alternatives. *Food Pol.* 111, 102310. <https://doi.org/10.1016/j.foodpol.2022.102310>.
- Dohmen, T., Falk, A., Huffman, D., Sunde, U., Schupp, J., Wagner, G.G., 2011. Individual risk attitudes: measurement, determinants, and behavioral consequences. *J. Eur. Econ. Assoc.* 9, 522–550. <https://doi.org/10.1111/j.1542-4774.2011.01015.x>.
- Embling, R., Neilson, L., Randall, T., Mellor, C., Lee, M.D., Wilkinson, L.L., 2022. 'Edible seaweeds' as an alternative to animal-based proteins in the UK: identifying product beliefs and consumer traits as drivers of consumer acceptability for macroalgae. *Food Qual. Prefer.* 100, 104613. <https://doi.org/10.1016/j.foodqual.2022.104613>.
- Estell, M., Hughes, J., Grafenauer, S., 2021. Plant protein and plant-based meat alternatives: consumer and nutrition professional attitudes and perceptions. *Sustainability* 13, 1–18. <https://doi.org/10.3390/su13031478>.
- FAO, 2018. *The Future of Food and Agriculture – Alternative Pathways to 2050*.
- Fehér, A., Gazdecki, M., Véha, M., Szakály, M., Szakály, Z., 2020. A comprehensive review of the benefits of and the barriers to the switch to a plant-based diet. *Sustainability* 12, 1–18. <https://doi.org/10.3390/su12104136>.
- Figueira, N., Curtain, F., Beck, E., Grafenauer, S., 2019. Consumer understanding and culinary use of legumes in Australia. *Nutrients* 11, 1–16. <https://doi.org/10.3390/nu11071575>.
- Florack, A., Koch, T., Haasova, S., Kunz, S., Alves, H., 2021. The differentiation principle: why consumers often neglect positive attributes of novel food products. *J. Consum. Psychol.* 31, 684–705. <https://doi.org/10.1002/jcpsy.1222>.
- Gallen, C., Pantin-Sohier, G., Peyrat-Guillard, D., 2019. Cognitive acceptance mechanisms of discontinuous food innovations: the case of insects in France. *Rech. Appl. Market.* 34, 48–73. <https://doi.org/10.1177/2051570718791785>.
- Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Faluccci, A., Tempio, G., 2013. Tackling Climate Change through Livestock – A Global Assessment of Emissions and Mitigation Opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.
- Godfray, H.C.J., Aveyard, P., Garnett, T., Hall, J.W., Key, T.J., Lorimer, J., Pierrehumbert, R.T., Scarborough, P., Springmann, M., Jebb, S.A., 2018. Meat consumption, health, and the environment. *Science* 361. <https://doi.org/10.1126/science.aam5324>.
- Gómez-Luciano, C.A., Vrieskoop, F., Urbano, B., 2019. Towards food security of alternative dietary proteins: a comparison between Spain and the Dominican Republic. *Amfiteatru Economic* 21, 393–407. <https://doi.org/10.24818/EA/2019/51/393>.
- Gordon, W., Gantori, S., Gordon, J., Leeman, R., Boer, R., 2019. The food revolution: trends disrupting the food industry [WWW Document]. URL. <https://www.ubs.com/global/en/ubs-society/our-stories/2019/future-of-food.html>.
- Grasso, A.C., Hung, Y., Olthof, M.R., Verbeke, W., Brouwer, I.A., 2019. Older consumers' readiness to accept alternative, more sustainable protein sources in the European Union. *Nutrients* 11. <https://doi.org/10.3390/nu11081904>.
- Greene, W., 2017. *Econometric Analysis*, eighth ed. Pearson.
- Guenther, P.M., Jensen, H.H., Batres-Marquez, S.P., Chen, C.F., 2005. Sociodemographic, knowledge, and attitudinal factors related to meat consumption in the United States. *J. Am. Diet Assoc.* 105, 1266–1274. <https://doi.org/10.1016/j.jada.2005.05.014>.
- Harnack, L., Mork, S., Valluri, S., Weber, C., Schmitz, K., Stevenson, J., Pettit, J., 2021. Nutrient composition of a selection of plant-based ground beef alternative products Available in the United States. *J. Acad. Nutr. Diet.* 121, 2401–2408.e12. <https://doi.org/10.1016/j.jand.2021.05.002>.
- Hartmann, C., Siegrist, M., 2017. Consumer perception and behaviour regarding sustainable protein consumption: a systematic review. *Trends Food Sci. Technol.* 61, 11–25. <https://doi.org/10.1016/j.tifs.2016.12.006>.

- Hielkema, M.H., Lund, T.B., 2021. Reducing meat consumption in meat-loving Denmark: exploring willingness, behavior, barriers and drivers. *Food Qual. Prefer.* 93 <https://doi.org/10.1016/j.foodqual.2021.104257>.
- Hoek, A.C., Luning, P.A., Weijzen, P., Engels, W., Kok, F.J., de Graaf, C., 2011. Replacement of meat by meat substitutes. A survey on person- and product-related factors in consumer acceptance. *Appetite* 56, 662–673. <https://doi.org/10.1016/j.appet.2011.02.001>.
- Hopwood, C.J., Bleidorn, W., Schwaba, T., Chen, S., 2020. Health, environmental, and animal rights motives for vegetarian eating. *PLoS One* 15, 20–24. <https://doi.org/10.1371/journal.pone.0230609>.
- Hu, F.B., Otis, B.O., McCarthy, G., 2019. Can plant-based meat alternatives be part of a healthy and sustainable diet? *JAMA, J. Am. Med. Assoc.* 322, 1547–1548. <https://doi.org/10.1001/jama.2019.13187>.
- Hwang, J., You, J., Moon, J., Jeong, J., 2020. Factors affecting consumers' alternative meats buying intentions: plant-based meat alternative and cultured meat. *Sustainability* 12. <https://doi.org/10.3390/su12145662>.
- Jahn, S., Furchheim, P., Strässner, A.M., 2021. Plant-based meat alternatives: motivational adoption barriers and solutions. *Sustainability* 13, 1–17. <https://doi.org/10.3390/su132313271>.
- Janda, S., Trocchia, P.J., 2001. Vegetarianism: toward a greater understanding. *Psychol. Market.* 18, 1205–1240. <https://doi.org/10.1002/mar.1050>.
- Jensen, N.H., Lieberoth, A., 2019. We will eat disgusting foods together – evidence of the normative basis of Western entomophagy-disgust from an insect tasting. *Food Qual. Prefer.* 72, 109–115. <https://doi.org/10.1016/j.foodqual.2018.08.012>.
- Kemper, J.A., White, S.K., 2021. Young adults' experiences with flexitarianism: the 4Cs. *Appetite* 160, 105073. <https://doi.org/10.1016/j.appet.2020.105073>.
- Kołodziejczak, K., Onopiuk, A., Szpicer, A., Poltorak, A., 2022. Meat analogues in the perspective of recent scientific research: a review. *Foods* 11. <https://doi.org/10.3390/foods11010105>.
- Kushwah, S., Dhir, A., Sagar, M., Gupta, B., 2019. Determinants of organic food consumption. A systematic literature review on motives and barriers. *Appetite* 143, 104402. <https://doi.org/10.1016/j.appet.2019.104402>.
- Marlow, H.J., Hayes, W.K., Soret, S., Carter, R.L., Schwab, E.R., Sabaté, J., 2009. Diet and the environment: does what you eat matter? *Am. J. Clin. Nutr.* 89, 1699S–1703S. <https://doi.org/10.3945/ajcn.2009.26736Z>.
- Martin, C., Lange, C., Marette, S., 2021. Importance of additional information, as a complement to information coming from packaging, to promote meat substitutes: a case study on a sausage based on vegetable proteins. *Food Qual. Prefer.* 87, 104058. <https://doi.org/10.1016/j.foodqual.2020.104058>.
- McBey, D., Watts, D., Johnstone, A.M., 2019. Nudging, formulating new products, and the lifecycle: a qualitative assessment of the viability of three methods for reducing Scottish meat consumption for health, ethical, and environmental reasons. *Appetite* 142, 104349. <https://doi.org/10.1016/j.appet.2019.104349>.
- Michel, F., Hartmann, C., Siegrist, M., 2021. Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives. *Food Qual. Prefer.* 87, 104063. <https://doi.org/10.1016/j.foodqual.2020.104063>.
- Migliore, G., Borrello, M., Lombardi, A., Schifani, G., 2018. Consumers' willingness to pay for natural food: evidence from an artefactual field experiment. *Agric. Food Econ.* 6, 1–10. <https://doi.org/10.1186/s40100-018-0117-1>.
- Migliore, G., di Gesaro, M., Borsellino, V., Ascuto, A., Schimmenti, E., 2015. Understanding consumer demand for sustainable beef production in rural communities. *CALITATEA-ACCES LA SUCCES* 16, 75–79.
- Naghshī, S., Sadeghi, O., Willett, W.C., Esmailzadeh, A., 2020. Dietary intake of total, animal, and plant proteins and risk of all cause, cardiovascular, and cancer mortality: systematic review and dose-response meta-analysis of prospective cohort studies. *The BMJ* 370. <https://doi.org/10.1136/bmj.m2412>.
- Onwezen, M.C., Bouwman, E.P., Reinders, M.J., Dagevos, H., 2021. A systematic review on consumer acceptance of alternative proteins: pulses, algae, insects, plant-based meat alternatives, and cultured meat. *Appetite* 159, 105058. <https://doi.org/10.1016/j.appet.2020.105058>.
- Onwezen, M.C., van den Puttelaar, J., Verain, M.C.D., Veldkamp, T., 2019. Consumer acceptance of insects as food and feed: the relevance of affective factors. *Food Qual. Prefer.* 77, 51–63. <https://doi.org/10.1016/j.foodqual.2019.04.011>.
- Perez-Cueto, F.J.A., Rini, L., Faber, I., Rasmussen, M.A., Bechtold, K.B., Schouteten, J.J., de Steur, H., 2022. How barriers towards plant-based food consumption differ according to dietary lifestyle: findings from a consumer survey in 10 EU countries. *Int J Gastron Food Sci* 29, 100587. <https://doi.org/10.1016/j.ijgfs.2022.100587>.
- Possidónio, C., Prada, M., Graça, J., Piazza, J., 2021. Consumer Perceptions of Conventional and Alternative Protein Sources: A Mixed-Methods Approach with Meal and Product Framing. <https://doi.org/10.1016/j.appet.2020.104860>. *Appetite* 156.
- Prada, M., Garrido, M.v., Rodrigues, D., 2017. Lost in processing? Perceived healthfulness, taste and caloric content of whole and processed organic food. *Appetite* 114, 175–186. <https://doi.org/10.1016/j.appet.2017.03.031>.
- Roininen, K., Lähteenmäki, L., Tuorila, H., 1999. Quantification of consumer attitudes to health and hedonic characteristics of foods. *Appetite* 33, 71–88. <https://doi.org/10.1006/appe.1999.0232>.
- Rothgerber, H., 2013. Real men don't eat (vegetable) quiche: masculinity and the justification of meat consumption. *Psychol. Men Masc.* 14, 363–375. <https://doi.org/10.1037/a0030379>.
- Rouhani, M.H., Salehi-Abargouei, A., Surkan, P.J., Azadbakht, L., 2014. Is there a relationship between red or processed meat intake and obesity? A systematic review and meta-analysis of observational studies. *Obes. Rev.* 15, 740–748. <https://doi.org/10.1111/obr.12172>.
- Santo, R.E., Kim, B.F., Goldman, S.E., Dutkiewicz, J., Bieh, E.M.B., Bloem, M.W., Neff, R.A., Nachman, K.E., 2020. Considering plant-based meat substitutes and cell-based meats: a public health and food systems perspective. *Front. Sustain. Food Syst.* 4, 1–23. <https://doi.org/10.3389/fsufs.2020.00134>.
- Schäufele, I., Barrera Albores, E., Hamm, U., 2019. The role of species for the acceptance of edible insects: evidence from a consumer survey. *Br. Food J.* 121, 2190–2204. <https://doi.org/10.1108/BFJ-01-2019-0017>.
- Schiano, A.N., Harwood, W.S., Gerard, P.D., Drake, M.A., 2020. Consumer perception of the sustainability of dairy products and plant-based dairy alternatives. *J. Dairy Sci.* 103, 11228–11243. <https://doi.org/10.3168/jds.2020-18406>.
- Sogari, G., Menozzi, D., Mora, C., 2016. Exploring young foodies' knowledge and attitude regarding entomophagy: a qualitative study in Italy. *Int J Gastron Food Sci* 7, 16–19. <https://doi.org/10.1016/j.ijgfs.2016.12.002>.
- Sucupane, D., Roux, C., Sobol, K., 2021. Exploring How Product Descriptors and Packaging Colors Impact Consumers' Perceptions of Plant-Based Meat Alternative Products. <https://doi.org/10.1016/j.appet.2021.105590>. *Appetite* 167.
- Szejda, K., Stumpe, M., Raal, L., Tapscott, C.E., 2021. South African consumer adoption of plant-based and cultivated meat: a segmentation study. *Front. Sustain. Food Syst.* 5, 1–14. <https://doi.org/10.3389/fsufs.2021.744199>.
- Szenderák, J., Fróna, R., Rákos, M., 2022. Consumer acceptance of plant-based meat substitutes: a narrative review. *Foods* 11. <https://doi.org/10.3390/foods11091274>.
- Testa, R., Ascuto, A., Schifani, G., Schimmenti, E., Migliore, G., 2019. Quality Determinants and Effect of Therapeutic Properties in Honey Consumption. An Exploratory Study on Italian Consumers, vol. 9. <https://doi.org/10.3390/agriculture9080174>. Agriculture (Switzerland).
- Testa, R., Galati, A., Schifani, G., Crescimanno, M., di Trapani, A.M., Migliore, G., 2020. Are alternative food networks winning strategies to increase organic SMEs profitability? Evidence from a case study. *Int. J. Glob. Small Bus.* 11, 65–82. <https://doi.org/10.1504/IJGSB.2020.105583>.
- Tso, R., Lim, A.J., Forde, C.G., 2021. A critical appraisal of the evidence supporting consumer motivations for alternative proteins. *Foods* 10, 1–28. <https://doi.org/10.3390/foods10010024>.
- UN Climate Change, 2021. We Need to Talk about Meat [WWW Document]. URL. <https://unfccc.int/blog/we-need-to-talk-about-meat>.
- Varela, P., Arvisenet, G., Goner, A., Myhrer, K.S., Fifi, V., Valentin, D., 2022. Meat replacer? No thanks! The clash between naturalness and processing: an explorative study of the perception of plant-based foods. *Appetite* 169, 1–10. <https://doi.org/10.1016/j.appet.2021.105793>.
- Verbeke, W., 2015. Profiling consumers who are ready to adopt insects as a meat substitute in a Western society. *Food Qual. Prefer.* 39, 147–155. <https://doi.org/10.1016/j.foodqual.2014.07.008>.
- Vita, G., Lundström, J.R., Hertwich, E.G., Quist, J., Ivanova, D., Stadler, K., Wood, R., 2019. The Environmental Impact of green consumption and sufficiency lifestyles scenarios in Europe: connecting local sustainability visions to global consequences. *Ecol. Econ.* 164, 106322. <https://doi.org/10.1016/j.ecolecon.2019.05.002>.
- Westling, M., Wennström, S., Öström, Å., 2022. Public meals as a platform for culinary action? Tweens' and teens' acceptance of a new plant-based food. *Int J Gastron Food Sci* 27. <https://doi.org/10.1016/j.ijgfs.2022.100485>.
- Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L.J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J.A., de Vries, W., Majele Sibanda, L., Afshin, A., Chaudhary, A., Herrero, M., Agustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M., Lindahl, T., Singh, S., Cornell, S.E., Srinath Reddy, K., Narain, S., Nishtar, S., Murray, C.J.L., 2019. Food in the anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *Lancet* 393, 447–492. [https://doi.org/10.1016/S0140-6736\(18\)31788-4](https://doi.org/10.1016/S0140-6736(18)31788-4).
- Wolk, A., 2017. Potential health hazards of eating red meat. *J. Intern. Med.* 281, 106–122. <https://doi.org/10.1111/joim.12543>.
- World Health Organization, 2015. Cancer: carcinogenicity of the consumption of red meat and processed meat [WWW Document]. URL. <https://www.who.int/news-room/questions-and-answers/item/cancer-carcinogenicity-of-the-consumption-of-red-meat-and-processed-meat>.
- Zhao, S., Wang, L., Hu, W., Zheng, Y., 2022. Meet the meatless: demand for new generation plant-based meat alternatives. *Appl. Econ. Perspect. Pol.* 1–18. <https://doi.org/10.1002/aep.13232>.