RESEARCH ARTICLE

Consumers' experiences and preferences for plant-based meat food: Evidence from a choice experiment in four cities of China

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Abstract

This paper examined consumers' experiences in and preferences for plant-based meat (PBM) food and their respective correlates, based on data from an online survey of 579 consumers in four major cities in China in early 2021. We first described consumers' experiences in consuming and purchasing PBM food and their correlates, and then analyzed consumer preferences using hypothetical choice experiment. The experiment offered consumers various options to purchase burgers made from PBM or animal-based meat (ABM), combined with different countries of origin (COO), taste labels, and prices. Our data showed that respondents hold overall positive attitudes toward PBM food; 85 and 82% of respondents reported experience in eating and purchasing PBM food, respectively. More than half of them ate PBM food because they wanted to try new food (58%), or were interested in healthy food (56%). Income, religion, and dietary restrictions were significantly correlated with consumers' experiences in PBM food consumption. Results from the Random Parameter Logit Model based on the hypothetical choice experiment data showed that 79% of respondents chose PBM burgers and were willing to pay an average of 88 CNY for a PBM burger. We also found that 99.8 and 83% of respondents are willing to buy burgers made in China and those with a taste label, with a willingness to pay (WTP) of 208 and 120 CNY, respectively. The heterogeneity test revealed that females and those with at least a bachelor's degree, higher income, religious beliefs, and dietary restrictions are more likely to buy PBM burgers than their counterparts.

Keywords: plant-based meat (PBM), choice experiment, consumers' preference, willingness to pay

1. Introduction

China has witnessed increasing meat consumption among its urban residents over the past four decades. Even ignoring food consumed away from home (Yu and Abler 2014), statistics show that urban pork consumption per capita increased from 16.9 kg in 1981 to 19.0 kg in 2020. During the same period, beef and mutton consumption per capita in urban areas increased from

1.7 to 4.5 kg. Accordingly, urban beef consumption rose from 1.64 million tons in 2013 to 2.8 million tons in 2020 (NBSC 2021; Zhu et al. 2021).

Increasing consumption of meat has given rise to a range of environmental and health concerns (McMichael et al. 2007; Bouvard et al. 2015; Godfray et al. 2018; Dai et al. 2021). According to FAO (2006), the livestock industry accounted for 18% of global greenhouse gas (GHG) emissions, 70% of all agricultural land, and 8% of global human water use. It is estimated that 70% of the energy was wasted during livestock production (Djekic 2015; He et al. 2020). In addition, red meat consumption also leads to a 7–19% increase in all-cause mortality rates (Pan et al. 2012; Vliet et al. 2020).

In recent years, there has been increasing interest in alternatives to animal-based meat (ABM), specifically plant-based meat (PBM) (Bryant et al. 2019). Relative to ABM food, the production of PBM food causes less GHG emissions and uses less land, water, and energy (Reijinders and Soret 2003). Moreover, PBM is more beneficial to the health of human beings as it contains more protein and fiber but less energy, total lipid (fat), and cholesterol than ABM (https://fdc.nal.usda.gov/fdc-app. html#/food-details/174036/nutrients).

Aware of its comparative strength, consumers record rising demand for PBM alternatives despite their relatively higher prices (Bryant et al. 2019). According to a report by IPSOS (2021), one of the largest market research companies around the world, PBM's market worth reached 12.1 billion dollars worldwide in 2019. Among all PBM products, the most popular are ingredients of burgers, such as patties, nuggets, and meatballs. As far as China is concerned, the main producers of PBM have shifted from foreign companies (e.g., Beyond Meat, USA) to domestic ones (e.g., Starfield, Shenzhen, China) over the past three years (USDA 2021). Moreover, with the advancement in PBM technology, both the flavor and taste of PBM are becoming increasingly similar to ABM, which is an important part of breaking the barrier to consumers' acceptance of PBM (Florian et al. 2014; Shen et al. 2021).

The topic of PBM alternatives is not new, but it is not until recently that PBM becomes one of the hottest topics in the food and research communities (He et al. 2020). When PMB first appeared in the 1960s (Florian et al. 2014), even among educated consumers, there was a wide concern about whether artificial meat could tackle the challenges associated with ABM production (Hocquette et al. 2015), including environmental damage (Bellarby et al. 2013), unhealthy development (Pan et al. 2012), and animal welfare (Hopwood et al. 2020). But some surveys conducted in China revealed that Chinese consumers have a higher acceptance of artificial meat

than their peers in other countries (Bekker et al. 2017; Bryant et al. 2019). Nonetheless, some scholars noted that promoting PBM may be challenging as consumers lack an understanding of PBM (Hartmann and Siegrist 2017; Bryant and Barnett 2018; Slade 2018; He et al. 2020).

Except for PBM, two other food attributes may affect consumers' food choices. One is the country of origin (COO), which is thought to reflect the quality of the products (Koschate-Fischer et al. 2012) and carry the cultural identity (Bruter 2004). The other is food taste. Some studies have shown that whether PBM tastes better or at least as good as ABM has always been the key to market opening (Slade 2018; Shen and Wang 2021).

PBM became available in some famous fast-food restaurants in China's first-tier cities in 2019 (Jin and Jiang 2020). Since then, big cities have remained the major markets of PBM in China. A recent report by T-Mall, one of China's biggest e-commerce platforms, suggested that young women in first- and second-tier cities accounted for around 60% of PBM product consumers (CBNData and Tmall 2020).

The COVID-19 pandemic has brought greater attention among consumers to health and sustainable development inside and outside China (Poon and Peiris 2020; Zhao 2020). Under such circumstances, some important questions arise. What is the prevalence of PBM consumption in China? What are the correlates? What is Chinese consumers' attitude toward PBM? What is their willingness to pay (WTP) for PBM food? Answers to these questions have important policy implications. Therefore, this paper seeks to answer these questions by drawing on a dataset of 579 urban consumers collated through an online survey in four cities in China: Beijing, Shanghai, Shenzhen, and Chongqing.

The rest of the paper is organized as follows. Section 2 introduces the data used in this study and presents the econometric model. Section 3 presents the empirical results and discussion. Section 4 concludes with some policy implications.

2. Data and methods

2.1. Data source

This study is based on data from an online survey of residents in four of China's major cities (Beijing, Shanghai, Shenzhen, and Chongqing) in early 2021. We selected urban residents in these four cities as our study sample for two reasons. First, many PBM products were first promoted in these cities when they entered China's markets (USDA 2021). Second, many PBM R&D companies are

headquartered in these cities, suggesting many continued market opportunities there (Percy 2019). In the meantime, we used beef burgers in fast-food restaurants as the product of interest for two reasons. On the one hand, the fast-food industry is the pioneering industry that brings PBM products to China. On the other hand, beef burgers are the most common fast-food products that use PBM products as ingredients (Slade *et al.* 2018).

This study randomly distributed the questionnaire to consumers through an online panel service provided by Wenjuanxing, one of China's biggest and most popular survey vendors. With its advantages of low cost, quick response, wide coverage, and professionalism, online panel service has gained popularity in facilitating responses (Smith *et al.* 2016; Bryant *et al.* 2019). There are many forms of online panels nowadays (Couper 2000; Huf and Siqueira 2019). This study took the service of "online panelists", a pool of individuals who have volunteered to participate in discontinuous consumer surveys *via* their Internet Panel Membership. The invitation to participate in the survey was randomly sent to 1 527 panelists in the pool who met the following two inclusion criteria simultaneously. First, the respondents must be older than 18 years. Second, they had lived in Beijing, Shanghai, Shenzhen, and Chongqing for more than three months by the time of the survey. In the survey invitation, it was said that the invited panelists would be rewarded 10 CNY if they completed the questionnaire and the completed questionnaire was approved as valid.

Validity approval of completed questionnaires was based on two criteria. One is eligibility, which requests that the questionnaire must be completed by an invited panelist as described above. The other is validity. A questionnaire will be deemed invalid if it falls into either of the three cases: 1) The respondent failed the attention check question in the middle of the survey; 2) questionnaires were completed with duplicate ID addresses; 3) the questionnaire was completed within 6 min, according to the log file of the survey. As it turned out, 687 (or 45%) of the 1 527 invitations sent out by Wenjuanxing were completed and submitted, of which 579 were valid, and the average response time was 14.66 min.

2.2. Questionnaire and sample characteristics

The questionnaire consists of three modules as follows.
Meat purchase and consumption experiences The survey collected data on consumers' meat purchase and consumption experiences. Specifically, respondents were asked about their PBM consumption and purchasing experience. Questions included whether a respondent has ever eaten any PBM food, whether she/he has

purchased any PBM food, where did she/he purchase PBM food, and what are the reasons for purchases. Respondents were also asked about their attitudes toward PBM, COO, and the taste label. Respondents were presented with seven statements and asked to what extent they agreed with each of them on a 5-point Likert Scale (from strongly disagree to strongly agree).
Hypothetical choice sets In a typical choice experiment, participants are presented with multiple decision scenarios and asked to choose the product option or alternative that they most prefer (Lin and Nayga 2022). Each decision scenario comprises several product alternatives with experimentally designed attribute levels, along with a no-purchase option to mimic a real market situation (Banzhaf *et al.* 2001). In the experiment of this study, we asked the respondents to imagine that they were in a fast-food restaurant and offered 24 alternatives to beef burgers along with the option of not purchasing. Specifically, we focused on four attributes of beef burgers: the type of patty (PBM or ABM), the COO ("made in China" or "made in foreign country"), the taste label on the package ("fresh and tender" or no taste label at all), and the price (13, 25, and 32 CNY).

As the study was conducted during the COVID-19 pandemic, we were not able to visit the shops/restaurants in person to check their menus for the price of burgers. Therefore, we took a three-step approach to set the price levels of burgers in our choice experiment. In the first step, we searched the e-commence apps in the four cities for ABM/PBM beef burgers and collected their prices. In the second step, we calculated the mean of the collected prices for ABM beef burgers. In the meantime, we ranked the collected prices for PBM burgers into two halves and calculated the mean for each half. In the final step, we set the mean prices for ABM, the bottom half PBM, and the top half PBM beef burgers as the low, medium, and high price levels, which are 13, 25, and 32 CNY, respectively.

Table 1 provides a summary of beef burgers' attributes and their levels. Given such attributes and their levels, a full factorial design would require 24 (=$2^3 \times 3^1$) different choice sets. In order to reduce the number of hypothetical products shown to respondents and potential choice fatigue, we conducted D-Optimal experimental design with *idefix* package in the statistical software R4.1 where choice sets that are repeated and deviated significantly from reality are eliminated (Burgess and Street 2005; Traets *et al.* 2020). This approach finally obtained eight choice sets, which were shown to respondents randomly to avoid any ordering effects and left-right bias (Chrzan 1994). A sample choice set (Table 2) shows that each choice set includes three product alternatives with experimentally designed attribute levels and an opt-out option.

Before the choice questions, respondents were

first given a brief description of PBM to help them better understand the alternatives to reduce potential hypothetical bias (List 2001). Then, we asked them whether they had eaten any burgers made from beef or PBM beef within the last year. If the answer is yes, the respondent was presented with the choice experiment; otherwise, he/she was deprived of the choice experiment and directed to the rest of the survey.

Respondent's characteristics The last module of the questionnaire collects information about the respondent's basic demographic characteristics, including age, gender, education, personal income in 2020, religion, and dietary restrictions.

Basic characteristics of sample respondents Table 3 presents the basic characteristics of the sample respondents. Of the 579 respondents, a majority (88%) were less than 40 years old, 67% were female, 82% held at least a bachelor's degree, and 55% had an income higher than 100 000 CNY in 2020. In terms of religion, 77% of them were not religious, whereas 12% practiced Buddhism, with the rest 11% holding Islamic, Catholic,

Table 1 Attributes and levels set in the beef burger choice experiment

Attributes[1]	Attribute level[2]
Type of patty	ABM beef, PBM beef
COO	Made in China, Made in a foreign country
Taste label	Fresh and tender, No-label
Price (CNY/Beef burger)	13, 25, 32

[1] COO, countries of origin.
[2] ABM, animal-based meat; PBM, plant-based meat.

Table 2 Sample choice set

Attributes	Option A	Option B	Option C	Option D
Meat type	ABM beef	PBM beef	PBM beef	If it's the only option, I will not choose any.
Country of origin	Foreign	China	Foreign	
Taste	No-label	Fresh and tender	No-label	
Price	13 CNY	25 CNY	32 CNY	

Table 3 Basic individual characteristics

Individual characteristics	All sample	Beijing	Shanghai	Shenzhen	Chongqing	*P*-value[1]
Number of observations	579	206	172	107	94	–
Female (%)	66.67	64.56	63.37	75.7	67.02	0.159
Age (%)						
18–24 years	12.09	15.53	8.72	12.15	10.64	0.091*
25–30 years	33.68	36.89	28.49	31.78	38.30	
31–40 years	43.52	36.89	51.16	47.66	39.36	
41–50 years	10.02	10.19	11.05	8.41	9.57	
>50 years	0.69	0.49	0.58	0	2.13	
Education (%)						
Compulsory education period	0.69	1.46	0.58	0	0	0.649
High school	3.11	2.43	4.07	4.67	1.06	
Junior college	14.68	10.19	15.7	18.69	18.09	
Bachelor's	70.81	74.27	66.86	66.36	75.53	
Master's or above	10.71	11.65	12.79	10.28	5.32	
Personal income in 2020 (%)						
≤30 000 CNY	13.65	11.65	11.62	14.95	20.22	0.677
30 000–50 000 CNY	6.56	8.74	4.07	7.48	5.32	
50 000–100 000 CNY	24.53	26.7	25	23.36	20.21	
100 000–300 000 CNY	40.41	38.83	45.93	39.25	35.11	
>300 000 CNY	14.86	14.08	13.37	14.95	19.15	
Religion (%)						
Islam	0.69	0.17	0	0	0.52	0.790
Buddhist	12.08	13.59	12.79	18.69	21.28	
Catholic	1.38	0.49	1.16	2.8	2.13	
Protestant	1.38	1.46	2.91	0	0	
Other	2.59	2.43	3.49	2.8	1.06	
Not religious	77.37	80.1	77.91	75.7	72.34	
Dietary restrictions (%)						
Veggie	8.81	9.22	8.72	9.35	7.45	0.508
Vegan	1.38	1.74	0.58	0	4.26	
Pescatarian	9.67	11.65	6.98	10.28	9.57	
Flexitarian	49.05	51.45	48.84	45.79	47.87	
None of the above	31.09	26.21	34.88	34.58	30.85	

[1] *P*-values are from Chi-square tests testing the null hypothesis of indifference between groups of variables across cities. * indicate significant at 10% level.

Protestant, or other religions. Speaking of dietary restrictions, 49% of the sample are flexitarians, 31% identified themselves as having no dietary restrictions at all, whereas 10%, 9%, and the rest 1% were pescatarian, vegetarian, and vegan, respectively. Compared with the 2020 Census data (NBSC 2021), our sample respondents are generally better educated, with a higher proportion of females. This is understandable given that PBM products are more popular among females than their male peers (He *et al.* 2020), and we expected respondents who participated in the online survey as internet users to be better educated. When we compare respondents' individual characteristics across the four cities, we did not find any statistically significant difference in almost all these indicators, with the only exception of age. Comparatively speaking, respondents from Beijing tended to be younger as Beijing had the highest proportion of respondents younger than 30.

2.3. Empirical model

We designed and implemented an online choice experiment to elicit Chinese consumers' preference for PBM burgers. Compared with other alternative methods of measuring respondents' preferences[1], the choice experiment has become a widely used stated preference technique for its theoretical consistency, flexibility in allowing participants to opt-out of making a choice, and the ability to elicit trade-offs among a broad set of attributes (Louviere *et al.* 2010; Lin and Nayga 2022). In a typical choice experiment, respondents are asked to choose between a set of hypothetical product options, and their preferences for different product attributes can thus be learned indirectly (Hanley *et al.* 1998).

Following the literature (Slade 2018; Lin and Nayga 2022), we used the Random Parameter Logit Model (RPLM) developed by McFadden and Train (2000). Compared with the Multi-Nominal Logit Model or Conditional Logit Model, RPLM relaxes the assumption of homogenous consumer preferences and has been widely used in the literature to analyze choice experiment data (Hensher and Greene 2003). The empirical model is specified as follows:

$$U_{njt}=V_{njt}+\varepsilon_{njt}$$
$$=\alpha price_{njt}+\beta_{n1}PBM_{njt}+\beta_{n2}Domestic_{njt}+\beta_{n3}taste_{njt}$$
$$+ASC_{opt-out}+\varepsilon_{njt} \tag{1}$$

where U_{njt} denotes the total utility that individual n derives

from choosing alternative j in the choice set t. V_{njt} denotes the systematic portion of the utility function that depends on the experimentally designed product attributes of alternative j. ε_{njt} is the random disturbance term. $price_{njt}$ denotes a continuous variable populated with the three price levels in the design, and α is price preference. PBM_{njt}, $Domestic_{njt}$, and $taste_{njt}$ are dummy variables for burger's patty type, COO, and taste label, respectively. They all take the value of 1 when the products carry such an attribute and 0 otherwise. β_s are the non-price attributes' coefficients. $ASC_{opt-out}$ is the alternative specific constant of the opt-out option, which is assumed to be invariant in the sample.

Based on estimation results from the RPLM, we can calculate consumers' willingness to pay (WTP) as follows (Hensher and Greene 2003):

$$WTP_{Attribute}=\frac{\partial U_{njt}/\partial Attribute}{\partial U_{njt}/\partial price}=-\frac{\beta_k}{\alpha} \tag{2}$$

where β_k is the estimated coefficient of the k-th attribute. In our case, k takes the value of n_1, n_2, and n_3, indicating the estimated coefficients associated with PMB, COO, and the taste label, respectively.

3. Results and discussion

3.1. Experiences, attitudes, and correlates

Respondents' PBM consumption and purchase experiences Table 4 describes respondents' experiences in PBM consumption and purchase. Of the 579 respondents, the majority have eaten (85%) or bought (82%) PBM before, and more than half of them had eaten sausages (53%) or burgers (51%) made from PBM. In most cases, they bought PBM products in supermarkets (68%) or online stores (41%). However, unlike previous literature that noted consumers pay more attention to the PBM's environmental effects (Bryant *et al.* 2019; He *et al.* 2020), more than half of our respondents reported that they ate PBM for reasons of trying new food (58%) or just being interested in healthy food (56%).

When looking into the respondents by sub-group, our data showed that their PBM consumption experiences varied significantly by city and dietary restriction but not by gender. Specifically, in terms of the share of consumers who once ate PBM food, Beijing ranked the highest (89%) among the four cities, followed by Chongqing (87%), Shenzhen (81%), and Shanghai (80%) (*P*-value<0.1). Meanwhile, the share was the highest at 94% among respondents who identified themselves as veggies (including vegetarians, vegans, and pescatarians), followed by Flexitarians (87%), with those with no dietary

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[1] Say, contingent valuation methods (CVM), experimental auctions, conjoint analysis and choice experiments (Breidert *et al.* 2006)

Table 4 Respondents' plant-based meat (PBM) eating and purchasing experiences

Classifications	All sample	Location					Gender			Dietary restrictions			
		Beijing	Shanghai	Shenzhen	Chongqing	P-value	Male	Female	P-value	Veggie[1]	Flexitarian	No-dietary restriction	P-value
Have you ever eaten any PBM? (1=Yes, 0=No)	0.85	0.89	0.80	0.81	0.87	0.058*	0.83	0.85	0.513	0.94	0.87	0.76	0.000***
Have you ever bought PBM products over the past three months? (1=Yes, 0=No)	0.82	0.86	0.77	0.80	0.85	0.107	0.81	0.83	0.488	0.90	0.85	0.73	0.000***
Have you ever eaten the following food made from PBM? (1=Yes, 0=No)													
Sausage	0.53	0.57	0.48	0.53	0.54	0.318	0.52	0.54	0.769	0.52	0.58	0.46	0.040**
Burger	0.51	0.58	0.46	0.48	0.49	0.081*	0.49	0.52	0.519	0.59	0.54	0.42	0.009***
Meatball	0.36	0.40	0.32	0.36	0.38	0.448	0.37	0.36	0.761	0.39	0.36	0.36	0.795
Rib	0.28	0.29	0.23	0.30	0.33	0.347	0.30	0.27	0.557	0.27	0.30	0.26	0.572
Lunch meat	0.27	0.26	0.30	0.24	0.27	0.783	0.28	0.26	0.692	0.27	0.30	0.22	0.190
Wonton	0.26	0.20	0.24	0.29	0.37	0.012**	0.21	0.28	0.081*	0.34	0.26	0.19	0.020**
Dumpling	0.23	0.23	0.19	0.25	0.27	0.494	0.24	0.20	0.294	0.28	0.25	0.17	0.049**
Fried chicken	0.18	0.17	0.17	0.22	0.20	0.699	0.20	0.18	0.544	0.23	0.19	0.14	0.145
Sandwich	0.15	0.17	0.13	0.13	0.17	0.668	0.12	0.17	0.191	0.20	0.15	0.12	0.149
Wrap	0.15	0.17	0.12	0.09	0.21	0.055*	0.16	0.15	0.806	0.17	0.17	0.11	0.128
Pizza	0.13	0.15	0.09	0.16	0.11	0.286	0.13	0.12	0.659	0.14	0.14	0.09	0.193
Fish and seafood	0.12	0.13	0.11	0.13	0.09	0.715	0.14	0.10	0.199	0.14	0.11	0.11	0.664
Pasta	0.11	0.11	0.07	0.10	0.19	0.026**	0.11	0.11	0.852	0.20	0.11	0.06	0.001***
Where did you buy PBM products? (1=Yes, 0=No)													
Supermarket	0.68	0.67	0.64	0.74	0.72	0.263	0.65	0.70	0.214	0.70	0.74	0.57	0.001***
Online	0.41	0.45	0.35	0.40	0.44	0.270	0.44	0.40	0.404	0.45	0.48	0.27	0.000***
Fast food restaurant	0.31	0.33	0.28	0.27	0.36	0.379	0.26	0.33	0.065*	0.37	0.31	0.27	0.152
Restaurant	0.23	0.25	0.22	0.22	0.22	0.812	0.26	0.21	0.163	0.25	0.23	0.22	0.779
Coffee shop	0.04	0.04	0.03	0.03	0.09	0.128	0.04	0.04	0.659	0.04	0.05	0.03	0.524
Why did you buy PBM products? (1=Yes, 0=No)													
Trying new food	0.58	0.60	0.60	0.61	0.48	0.189	0.59	0.58	0.859	0.56	0.57	0.62	0.485
Being interested in healthy food	0.56	0.55	0.52	0.59	0.63	0.370	0.53	0.58	0.261	0.62	0.64	0.41	0.000***
Health consideration	0.36	0.40	0.28	0.34	0.47	0.009***	0.37	0.36	0.903	0.37	0.42	0.28	0.009***
Environmental protection	0.31	0.29	0.26	0.37	0.36	0.131	0.31	0.31	0.949	0.41	0.37	0.15	0.000***
Animal welfare	0.06	0.05	0.05	0.05	0.09	0.636	0.05	0.06	0.448	0.06	0.06	0.04	0.680
Religion	0.02	0.03	0.01	0.03	0.02	0.556	0.02	0.03	0.703	0.09	0.01	0.01	0.000***

[1] Veggie includes vegetarians, vegans, and pescatarians.
*, **, and *** indicate significant at 10, 5, and 1% levels, respectively.

restrictions ranking the lowest at 76% (*P*-value<0.01). In contrast, there appears to be no gender pattern in this share, with 83% for males against 85% for females.

As to their PBM purchasing experiences, the share of respondents who once purchased PBM products over the past three months varied significantly by dietary restriction but not by city or gender. In particular, 90% of veggies reported that they did such purchasing, against 85% among flexitarians and 73% among those with no restrictions (*P*-value<0.01). In contrast, this share ranged between 77 and 86% in the four cities, but the difference was not statistically significant. There appeared to be no obvious pattern in this share by gender either, with 81% for males against 83% for females.

Regarding respondents' experiences in eating the 13 selected PBM food items, descriptive analyses showed that dietary restrictions played a better role in predicting respondents' propensity to have eaten any PMB food items, followed by city and gender. Specifically, the eating propensity varied significantly in five (sausages, burgers, wontons, dumplings, and pasta) out of the 13 PBM food items by dietary restriction, against four (burgers, wontons, wraps, and pasta) by city and only one (wonton) by gender. In terms of the PBM food items, the propensity of consumers to have eaten PBM wontons varied in all the three dimensions. In particular, the share of respondents who reported eating PBM wontons ranged from 20% in Beijing to 37% in Chongqing (*P*-value<0.05). Meanwhile, the share ranged from 19% among those without dietary restrictions to 34% among veggies (*P*-value<0.05). While 21% of males reported that they once ate PBM wontons, 28% of their female peers reported that they had done so (*P*-value<0.1). Moreover, the share of respondents who reported eating PBM burgers ranged from 46% in Shanghai to 58% in Beijing (*P*-value<0.1). Similarly, the share ranged from 46% among those without dietary restrictions to 59% among veggies (*P*-value<0.01).

As to the venues of purchasing PBM food, the share of respondents who reported supermarket or online purchases varied significantly by dietary restriction but not by city or gender. In particular, 74 and 48% of respondents who identified themselves as flexitarians bought from supermarkets and online, respectively; the rates were 70 and 45% for veggies and 57 and 27% for those with no dietary restrictions (*P*-value<0.01). In addition, the share of respondents who reported they bought PBM food from fast-food restaurants varied significantly by gender, with 26% for males against 33% for females (*P*-value<0.1).

Regarding the reasons for purchasing PBM food, our data showed that buying PBM for being interested in healthy food, environmental protection, or religion varied significantly (at the 1% level) by dietary restriction but not by city or gender. Specifically, the share of respondents who reported being interested in healthy food and having health considerations as the reasons was the highest among flexitarians at 64 and 42%, followed by veggies at 62 and 37% and those with no dietary restriction at 41 and 28%, respectively, with *P*-values less than 0.01. In contrast, veggies hold the highest share of the respondents who bought PBM food for environmental protection and religion at 41 and 9%, followed by flexitarians at 37 and 1% and those with no dietary restriction at 15 and 1%, respectively. In the meantime, the share of respondents who bought PBM food for health considerations was the highest in Chongqing (47%), followed by Beijing (40%), Shenzhen (34%), and Shanghai (28%) (*P*-value<0.01).

Respondents' attitudes toward food attributes In order to examine respondents' attitudes toward PBM, COO, and taste labels of food, we asked them to respond to seven statements using a 5-point Likert Scale (from strongly disagree to strongly agree) (Table 5). We created their attitude score *via* a two-step procedure with their responses to each of the seven statements. In the first step, for each statement (1), (3), and (5), one point was allocated for choices of "strongly disagree" or "disagree" and zero for "agree" or "strongly agree". In contrast, for each statement (2), (4), (6), and (7), one point was allocated for either "agree" or "strongly agree", and zero for "strongly disagree" or "disagree". In the second step, we added the points of the seven statements to construct the attitude score, ranking from 0 to 7 points.

As shown in Table 5, the average attitude score of the respondents is 3.74, with significant variations by gender and dietary restriction. Specifically, female respondents had an average attitude score of 3.86, significantly higher than their male peers (3.51). As to dietary restrictions, veggies had the highest attitude score (4.33), followed by flexitarian (3.93), with the lowest among those without any dietary restrictions (3.07). Moreover, the variations are significant at a 5% level in both cases.

When looking at their responses to the five statements about PBM, our data showed that respondents held quite positive attitudes toward PBM, with significant variations across sub-groups. Specifically, in response to the statement "Compared with PBM, I prefer ABM", 28% responded that they "strongly disagree" or "disagree" with it, with significant variations by gender (*P*-value<0.01) and dietary restriction (*P*-value<0.01). As to the statement "I know where to buy PBM", 71% indicated "agree" or "strongly agree" with significant variations by city (*P*-value<0.1) and dietary restriction (*P*-value<0.01). When it comes to the statement "ABM is good for the

Table 5 Respondents' attitudes toward plant-based meat (PBM), countries of origin (COO), and taste labels

Attitudes about attributes[1]	All sample	Locations					Gender			Dietary restrictions			
		Beijing	Shanghai	Shenzhen	Chongqing	P-value	Male	Female	P-value	Veggie	Flexitarian	No-dietary restriction	P-value
Attitude score	3.74	3.80	3.69	3.46	4.04	0.461	3.51	3.86	0.042**	4.33	3.93	3.07	0.000***
(1) "Compared with PBM, I prefer ABM."	28%	29%	25%	24%	33%	0.423	22%	31%	0.005***	43%	31%	12%	0.000***
(2) "I know where to buy PBM."	71%	76%	70%	65%	69%	0.055*	71%	71%	0.522	82%	75%	59%	0.000***
(3) "ABM is good for the environment."	45%	46%	48%	39%	48%	0.505	39%	49%	0.038	47%	49%	39%	0.504
(4) "The nutrition of PBM can replace the nutrition of ABM."	49%	50%	47%	45%	56%	0.616	44%	51%	0.124	63%	51%	36%	0.000***
(5) "ABM is very important to a healthy diet."	21%	22%	20%	16%	24%	0.323	17%	23%	0.001***	31%	23%	12%	0.000***
(6) "I prefer to read labels on food products."	86%	84%	87%	84%	90%	0.119	87%	85%	0.662	83%	88%	83%	0.362
(7) "Compared to foods produced in foreign countries, I prefer to buy foods produced in China."	75%	74%	73%	72%	83%	0.119	73%	76%	0.429	84%	76%	67%	0.588

[1] We show the proportions of respondents who "disagree" or "strongly disagree" in Rows (1), (3), and (5), whereas the proportions of respondents who "agree" or "strongly agree" in Rows (2), (4), (6), and (7), respectively. ABM, animal-based meat. *, **, and *** indicate significant at 10, 5, and 1% levels, respectively.

environment", 45% reported "strongly disagree" or "disagree" with no obvious pattern across sub-groups. In terms of nutrition, 49% reported "agree" or "strongly agree" with the statement "The nutrition of PBM can replace the nutrition of ABM" with significant variations by dietary restriction (P-value<0.01). Lastly, from the health perspective, 21% chose "strongly disagree" or "disagree" with the statement "ABM is very important to a healthy diet", with significant variations by gender (P-value<0.01) and dietary restriction (P-value<0.01).

As to their responses to food taste labels and COO, most respondents agreed or strongly agreed with the statements, with no obvious pattern across sub-groups. Specifically, 86% of the respondents agreed or strongly agreed with the statement that "I prefer to read labels on food products", while 75% agreed or "strongly agreed with the statement that "Compared to foods produced in foreign countries, I prefer to buy foods produced in China", with no significant variations across cities, genders, or dietary restrictions.

Correlation between respondents' characteristics and their PBM eating and purchasing experiences To further examine the relationship between respondents' characteristics and their PBM eating and purchasing experiences, we applied a Probit Model. The dependent variables are dummy variables indicating whether they have eaten or purchased any PBM food. Following the literature (Hocquette et al. 2015; Slade 2018; Bryant et al. 2019; He et al. 2020), we focused on four groups of individual characteristics. The first group contains two demographic variables: female (one if female and zero otherwise) and age (a set of four dummy variables with those elder than 50 years as the base). The second group consists of two socio-economic variables: education (a set of four dummy variables with those whose education is less than senior high school as the base) and income (a set of four dummy variables with those whose income in 2020 was less than 30 000 CNY as the base). The third group is a set of five religion dummy variables (with those non-religious as the base). The fourth group is a set of two dietary dummy variables (with those without any dietary restrictions as the base). In the meantime, we also included three city dummy variables (with Beijing as the base) to control for any factors at the city level and above that might correlate with respondents' eating and purchasing experiences of PBM food.

The Probit model showed that respondents with higher incomes, religions or dietary restrictions were more likely to have eaten or bought PBM food (Table 6). Our results also showed that respondents' income, religions, and dietary restrictions were significantly correlated with their PBM eating experiences. Specifically, compared with those whose income in 2020 was less than 30 000 CNY, respondents with incomes between 30 000 and 50 000 CNY and more than 300 000 CNY were 13 and 15% more likely to have eaten PBM food, respectively, and the result was statistically significant at the 5 and 1% levels. Compared with their non-religious peers, Muslims were 46% less likely to have eaten PBM (P-value<0.1), whereas Buddhists were 12% more likely

Table 6 Estimation results of Probit models

	Have eaten plant-based meat (PBM)				Have bought plant-based meat (PBM) products			
	Coef.	Std. Err	Marginal effect	Std. Err	Coef.	Std. Err	Marginal effect	Std. Err
Female (1=Yes)	0.07	0.15	0.01	0.03	0.07	0.14	0.02	0.03
Age group (years)								
18–24	0.93	0.86	0.24	0.28	0.09	0.85	0.25	0.28
25–30	0.71	0.86	0.20	0.28	0.61	0.08	0.18	0.28
31–40	0.39	0.87	0.12	0.28	0.30	0.85	0.09	0.28
41–50	1.23	0.90	0.29	0.28	0.87	0.87	0.24	0.28
>50[1]								
Education group								
Less than high school[1]								
High school	0.48	0.93	0.14	0.29	0.69	0.91	0.21	0.30
Junior college	1.37	0.89	0.31	0.28	1.30	0.88	0.33	0.29
Bachelor's	0.76	0.87	0.21	0.28	0.77	0.85	0.23	0.28
Master's or above	0.75	0.89	0.21	0.28	0.62	0.87	0.19	0.29
Income group (CNY)								
≤30 000[1]								
30 000–50 000	0.74*	0.43	0.13**	0.07	0.61	0.38	0.13	0.07
50 000–100 000	0.24	0.25	0.05	0.06	0.25	0.24	0.06	0.06
100 000–300 000	0.004	0.23	0.001	0.06	–0.03	0.22	–0.01	0.06
>300 000	0.90***	0.34	0.15***	0.06	0.88***	0.31	0.16***	0.06
Religions								
Not religious[1]								
Islam	–1.48**	0.75	–0.46*	0.24	–1.20	0.74	–0.39	0.25
Buddhist	0.78***	0.28	0.12***	0.03	0.78***	0.26	0.14***	0.03
Catholic	–0.32	0.60	–0.08	0.17	–0.15	0.59	–0.04	0.16
Protestant	–0.04	0.53	–0.01	0.12	0.06	0.53	0.02	0.13
Other	0.61	0.48	0.10*	0.06	0.76	0.48	0.13	0.06
Dietary restrictions								
No-dietary restrictions[1]								
Veggie	0.78***	0.23	0.15***	0.04	0.63***	0.21	0.14***	0.04
Flexitarian	0.37**	0.15	0.08**	0.04	0.41***	0.15	0.10***	0.04
City								
Beijing[1]								
Shanghai	–0.31*	0.18	–0.06*	0.04	–0.28*	0.17	–0.06*	0.04
Shenzhen	–0.36*	0.20	–0.07*	0.04	–0.26	0.20	–0.06	0.05
Chongqing	–0.04	0.23	–0.01	0.04	–0.04	0.22	–0.01	0.04
Constant	–1.00	1.09	–	–	–1.04	1.08	–	–
LR chi^2			72.55***				72.14***	
Pseudo R^2			0.1470				0.1338	

[1] Reference group.
*, **, and *** indicate significant at 10, 5, and 1% levels, respectively.

(*P*-value<0.01). Consistent with Bryant and Julie (2018) and He *et al.* (2020), our regression results showed that respondents with dietary restrictions were more likely to have eaten PBM. In particular, compared with those without any dietary restrictions, veggies and flexitarians were 15 and 8% more likely to have eaten PBM, respectively, and the result was significant at the 1 and 5% levels. Moreover, compared with their peers in Beijing, respondents in Shanghai and Shenzhen were less likely to have eaten PBM, whereas those in Chongqing exhibited little difference.

Our results also showed that respondents' income in 2020, religion, and dietary restrictions were significantly correlated with their PBM purchasing experiences. In particular, compared with respondents whose income in 2020 was less than 30 000 CNY, those with income of more than 300 000 CNY were 16% more likely to have bought PBM food (*P*-value<0.1). Speaking of religions, compared with their non-religious peers, Buddhists were 14% more likely to have bought PBM food (*P*-value<0.01). In the meantime, compared with those without any dietary restrictions, veggies and flexitarians were 14 and 10% more likely to have bought PBM food, respectively (*P*-value<0.01). Lastly, compared with their peers in

Beijing, respondents in Shanghai were less likely to have bought PBM, whereas those in Shenzhen and Chongqing exhibited little difference.

3.2. Basic model of RPLM

In the choice experiment, all the 465 respondents who self-reported that they had eaten burgers made from either beef or PBM beef over the past year were asked to complete eight choice sets, each containing four options. This design generated a total of 14 880 (=465×8×4) observations. We first estimated eq. (1) using Random Parameter Logit Model to examine consumers' preferences for burger attributes. We then calculated WTP with eq. (2) with those estimated coefficients from eq. (1). Table 7 reports the results.

The basic model demonstrated four important findings.

First, all the four product attributes significantly affected consumers' burger selection, with expected signs of all coefficients. Of all 465 respondents, 79% preferred buying PBM burgers compared to ABM. As for COO, the proportion was 100%, suggesting all the respondents would like to buy domestic burgers rather than foreign ones. Regarding taste labels, 83% preferred to buy burgers with fresh and tender labels.

Second, as the simulated WTP and its 95% confidence interval revealed, consumers would like to pay 87.61 CNY for PBM burgers. The values are much more than the results from Van Loo *et al.* (2020), who found that the WTP of the US consumers is 4.16 USD (or 29 CNY) for the PBM using pea protein and 2.92 USD (or 20 CNY) for the PBM using animal-like proteins produced by yeast[2]. Even when compared with the highest real market price of 32 CNY per burger in China at the time of the survey,

Table 7 RPLM results by all samples and flexitarian and non-flexitarian sub-samples

Variable[1]	Coef. mean	Coef. SD	Proportion[2]	WTP	WTP's 95% C.I.
All sample					
PBM (1=yes, 0=no)	0.61 (0.08)***	0.76 (0.18)	0.79	87.61 (30.96)***	[26.92, 148.29]
Made in China (1=yes, 0=no)	1.46 (0.11)***	0.10 (0.44)	1.00	208.41 (74.29)***	[62.81, 354.02]
Fresh and tender label (1=yes, 0=no)	0.84 (0.06)***	0.87 (0.27)	0.83	120.16 (43.96)***	[33.99, 206.33]
Price	−0.007 (0.002)***				
ASC	31.08 (0.41)***				
Log likelihood	−3 997.22				
AIC	8 010.44				
BIC	8 060.22				
Observations	14 880				
Flexitarian					
PBM (1=yes, 0=no)	0.81 (0.11)***	0.44 (0.48)	0.97	114.07 (61.28)*	[−6.029, 234.17]
Made in China (1=yes, 0=no)	1.54 (0.16)***	0.83 (0.32)	0.97	217.37 (119.41)*	[−16.67, 451.41]
Fresh and tender label (1=yes, 0=no)	0.78 (0.08)***	0.69 (0.47)	0.87	110.57 (62.44)*	[−11.81, 232.95]
Price	−0.007 (0.004)*				
ASC	29.19 (0.59)***				
Log likelihood	−1 929.04				
AIC	3 876.07				
BIC	3 925.70				
Observations	7 382				
Non-flexitarian					
PBM (1=yes, 0=no)	0.42 (0.11)***	0.83 (0.23)		64.03 (32.34)**	[0.64, 127.41]
Made in China (1=yes, 0=no)	1.39 (0.16)***	0.08 (0.06)		211.60 (105.54)**	[4.74, 418.47]
Fresh and tender label (1=yes, 0=no)	0.93 (0.09)***	0.92 (0.41)		140.93 (71.06)**	[1.66, 280.21]
Price	−0.007 (0.003)**				
ASC	29.52 (0.63)***				
Log likelihood	−2 058.39				
AIC	4 134.79				
BIC	4 184.68				
Observations	7 552				

[1] PBM, plant-based meat; ASC, alternative specific constant; AIC, Akaike information criterion; BIC, Bayesian Information Criterions.
[2] Proportion refers to the proportion of respondents who demonstrated a preference for the burgers attribute in question.
Standard errors, clustered on the individual, are in parentheses. *, **, and *** indicate significant at 10, 5, and 1% levels, respectively.

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[2] 1 USD=6.90 CNY at that time.

the estimated WTP for PBM is quite high. Specifically, the estimated WTP for all sample, flexitarian, and non-flexitarian respondents were 88, 114, and 64 CNY, respectively. In other words, respondents were willing to pay at least twice the highest real market price for the PBM burgers. This result is in stark contrast with what Slade (2018) found five years ago in Canada, where consumers' WTP for PBM was negative.

There are at least three possible reasons behind such a high estimated WTP. First, our sample respondents were highly educated (82% had at least a college degree) with a high income level (55% had an annual income greater than 100 000 CNY in 2020) from four of China's major cities. As shown by Bryant *et al.* (2019), highly educated people with high incomes tend to be more willing to pay more for PBM. Second, respondents' stated preference may be higher than real preference because they know they are participating in a survey (Shogren *et al.* 1999). Third, a high proportion (49%) of respondents self-identified as flexitarians. According to Slade (2018), flexitarians tend to be more motivated by the expectation of eating less meat and more vegetarian food, thus more willing to pay more for PBM. To examine whether the high proportion of flexitarians is to blame for the high estimated WTP for PBM, we calculated the WTP for PBM by flexitarian and non-flexitarian respondents and added the results to Table 7. As it turned out, the WTP for PBM by flexitarians was almost twice that of non-flexitarians (114 *vs*. 64 CNY), suggesting that the high proportion of flexitarians is one of the reasons behind the high estimated WTP.

Our results also showed that respondents were willing to pay an extremely high price (208.41 CNY) for domestic products, which is 6.5 times more than the price of a burger. This WTP is much higher than that for the COO of steaks (2.568 USD, or 21.25 CNY) found by Loureiro and Umberger (2007). A possible explanation is that our survey took place in early 2021, a critical time after the COVID-19 pandemic. At that time, China's anti-epidemic policies had greatly aroused patriotic feelings (Liu and Huang 2020), leading to a greater preference for domestic products. Wang and Chen (2004) also believed that consumers are willing to buy domestic products, especially in developing countries, because of ethnocentrism.

Finally, consumers' preference to read labels makes them willing to pay 120.16 CNY for the "fresh and tender" label on burgers. According to Mizutani *et al.* (2012), label or package images modulate flavors in consumers' memory. Since all the respondents had eaten burgers made from either beef or PBM beef over the past year, the "fresh and tender" label on the burger's package might evoke their taste memory, making them willing to pay more.

3.3. Heterogeneity

The results showed that all the four product attributes were significantly correlated with the WTP of average consumers for burgers. In order to examine whether these correlations vary across respondent sub-groups, we conducted heterogeneity analyses by respondents' gender, education, income, religion, and dietary restrictions, which are significant characteristics shown in the above analyses. Based on the sample distribution, we classified consumers into different sub-groups in the following way: respondents with a bachelor's degree or above were categorized as the highly educated group and the rest as the lowly-educated group; those with an annual income of 300 000 CNY or more in 2020 as the high-income group and the rest as the low-income group; those with religious belief as the religious group and the rest as the non-religious group; those eating meat (including vegetarian who occasionally consumes meat and consumers who have no dietary restriction) as the non-dietary restriction group and the rest as the dietary restriction group.

Results from heterogeneity analyses showed that the correlation between burger attributes and consumers' WTP for them varied by sub-group (Table 8). Specifically, female, highly educated, and high-income consumers are more receptive to the attributes of burgers compared to their male, lowly-educated, and low-income peers. To illustrate, the average WTP for PBM burgers was 66.36, 96.20, 91.63 CNY for female, highly educated, and higher-income respondents, respectively. In contrast, null effects were found in their male, lowly education, and low-income peers. Moreover, consistent with the literature (e.g., He *et al.* 2020; Vliet *et al.* 2020), consumers with religion and dietary restrictions showed a stronger preference for PBM (Appendix A) than their non-religious and no dietary restriction counterparts. However, null effects were found by religion or dietary restriction groups in WTP because of the insignificant coefficient of price. Cautions should be taken when interpreting the results on WTP for PBM beef burgers, as different religions have different disciplines on eating.

In terms of COO, females were willing to pay 168.92 CNY for domestic products. Highly educated and high-income respondents strongly preferred domestic burgers, willing to pay 219.63 and 161.40 CNY, respectively. Respondents with no religion or dietary restrictions were willing to pay 190.62 or 202.99 CNY for domestic burgers, respectively.

Table 8 Heterogeneity in willingness to pay (WTP) (CNY/burger)

	Female	Male	Highly-education	Lowly-education	High-income	Low-income	Religious	Non-religious	Dietary restriction	No-dietary restriction
PBM	66.36***	233.55	96.20**	61.48	91.63***	80.36	201.15	64.99***	200.50	62.59**
	(20.51)	(453.15)	(41.00)	(39.86)	(33.27)	(86.52)	(195.37)	(25.04)	(140.48)	(27.00)
Made in China	168.92***	489.37	219.63**	179.30	161.40***	405.06	309.54	190.62***	248.24	202.99**
	(31.58)	(964.17)	(94.59)	(118.49)	(57.94)	(469.68)	(303.63)	(73.04)	(173.92)	(88.60)
Fresh and tender label	98.51***	286.53	131.25**	90.03	75.41***	310.26	146.07	117.01***	136.56	125.44**
	(31.58)	(569.01)	(58.15)	(62.83)	(27.68)	(366.16)	(149.62)	(45.90)	(101.32)	(56.48)
Observations	9 952	4 928	12 000	2 880	8 128	6 752	3 712	11 168	2 944	11 936

Standard errors, clustered on the individual, are in parentheses. *, **, and *** indicate significant at 10, 5, and 1% levels, respectively.

As to taste labels, compared with the null effects in WTP found among their male, lowly educated, and low-income peers, the female, highly educated, and higher-income respondents were willing to pay 98.51, 131.25, and 75.41 CNY, respectively. Similarly, respondents with no religion and dietary restrictions were willing to pay 117.01 and 125.44 CNY, respectively, for "fresh and tender" labeled burgers.

4. Conclusion and implications

Drawing on data from an online survey among 579 consumers in four of China's major cities in early 2021, this study examined Chinese consumers' experiences in plant-based meat (PBM) purchasing and consumption and their preferences for PBM burgers using a hypothetical choice experiment. We found that overall, consumers held a positive attitude toward PBM, and more than four out of five respondents had eaten (85%) or bought (82%) PBM food. Furthermore, the top two self-reported reasons behind PBM consumption were: trying new food (58%) and being interested in healthy food (56%). We also found that consumers who are Buddhists with higher incomes and dietary restrictions (veggie and flexitarian) were more likely to have eaten or bought PBM products. The Random Parameter Logit Model results further indicated that consumers were willing to pay 88, 208, and 120 CNY for the PBM, domestic food, and "fresh and tender" label, respectively. Moreover, their preferences for these burger attributes were linked to their gender, education, income, religion, and dietary restrictions.

Our findings offer at least three implications. First, since most consumers have consumption experiences in PBM with a positive attitude and have a high WTP for PBM, country of origin, and the taste label, PBM manufacturers would benefit significantly by tapping the market potential and better serving the consumers. Second, consumers who are wealthier, religious, or with dietary restrictions should be the focus of market targeting, as they are more likely to eat or buy PBM food.

At least two limitations should be acknowledged. First, we might have overestimated the WTP for PBM because most respondents in this study were flexitarian, highly educated, wealthy, and young in China's large cities. Second, the choice experiment is a hypothetical one in a specific context. Although choice experiments have been found to have real-world validity (Chang *et al.* 2009), consumers may deviate from the hypothetical choice result when they can see and touch the actual commodity (Lin and Nayga 2022). Third, caution should be taken when generalizing the findings from this study as we only applied one beef scenario. More research is needed to understand whether consumer preferences for PBM would vary when beef is replaced with other types of meat.

Acknowledgements

Declaration of competing interest

The authors declare that they have no conflict of interest.

Appendix associated with this paper is available on http://www.ChinaAgriSci.com/V2/En/appendix.htm.

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