Understanding the Role of Food Neophobia in the Willingness to Consume Functional Rice

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Abstract: Understanding consumer preferences for new foods, such as functional rice, is crucial for developing varieties that meet consumer needs and promote health. Our research, incorporating a hybrid discrete choice model and psychometric data, reveals that food neophobia significantly contributes to hesitancy in consuming functional rice. Additionally, we found that being female, childless, and having lower levels of education and income are associated with higher levels of food neophobia. Based on a sample of 1,666 Chinese respondents, these findings underscore the potential impact of functional rice on consumer health. The health benefits of functional rice strongly appeal to consumers, especially those with a good understanding of the concept, who engage in regular exercise, or who have health issues. In particular, respondents preferred micronutrient-enhanced rice to low GI and gluten varieties when comparing various health benefits. Notwithstanding, individuals who suffer from kidney disease show a strong preference for the low-gluten variety. A segment analysis confirms these results, indicating a preference for functional rice, particularly the micronutrient-enhanced variety, among diverse consumer segments. Finally, in general, educated, younger, and wealthier individuals are more likely to choose functional rice.

Keywords: functional rice, food neophobia, hybrid choice models, health benefits, consumer preferences

1. Introduction

The global progress in addressing food security and reducing hunger has been significant over the past few decades. However, a new challenge has emerged regarding the lack of essential vitamins and minerals needed to meet people's nutritional needs (Lowe, 2021). It is crucial to address the risk of diseases such as obesity, high blood pressure, and kidney failure, which are threats to populations worldwide (Küster-Boluda & Vidal-Capilla, 2017). In response, functional agricultural products, which are rich in certain micronutrients (or have other health benefits in reducing the risk of diseases), but do not significantly differ in appearance from their conventional counterparts (Roberfroid, 2000), have gained recognition as potential solutions to combat excess energy consumption and nutrient deficiencies (Larson et al., 2021; Patel, 2015). Examples of *micronutrient-enhanced* foods include but are not limited to lycopene-rich tomato (Timpanaro et al., 2020), Omega-3-fortified eggs (Tian et al., 2022), and zinc-biofortified rice (Woods et al., 2020). However, despite the promising prospects of functional agricultural products, many end up as market failures due to its low acceptance by consumers (Santeramo et al., 2017). Given the significant investment in the research and development of functional varieties and their crucial impact on health improvement, it is essential to understand consumer preferences and concerns regarding various types of crops.

Our research focuses on *functional rice*, a technological mature product that is gaining

recognition for its potential health benefits but still faces challenges in consumer acceptance. The motivation for this study is to understand Chinese consumer preferences for functional rice, particularly how *food neophobia* influences these preferences. Food neophobia, defined as an aversion to novel foods, has been considered as one of the obstacles to functional foods (Dolgopolova et al., 2015; Ortega et al., 2022), but evidence on its direct effect on functional agricultural product consumption is still limited. Furthermore, research on the demographic determinants of food neophobia in adults in China, a key market for functional rice, is relatively scarce.

We employ a hybrid discrete choice model with error components. This approach allows us to incorporate the psychometric data measuring food neophobia as a latent variable, examining its influence on consumer preference in a more advance way. While food neophobia is our primary focus, our model also enables us to examine the role of additional factors such as cognitive ability, lifestyle, health conditions, and more classic demographic variables, providing a comprehensive view of the determinants of consumer preferences for functional rice. To translate these preferences into market potential, we conduct a segment analysis, which allows us to predict the potential uptake of different rice alternatives in different segments of market. This complements the discrete choice analysis and provides policy implications for marketing strategies.

The rest of the paper is organised as follows. In the next section we briefly review the relevant literature and justify our hypotheses. Section 3 elaborates on the econometric models. Section 4 describes our methodology, and the experiment results are analysed in Section 5. Finally, Section 6 summarises our main conclusions.

2. Brief Review of Literature and Development of Hypotheses

The existing literature suggests several factors that may explain consumers' purchase decisions among functional and conventional food alternatives. Additional health benefits might be the most important attribute that distinguishes functional agricultural products from conventional ones, yet some functional varieties may not be attractive in terms of their claimed health benefits, or the perceived reward associated with consuming them (Chammas et al., 2019; Maeda-Yamamoto, 2017; Nong et al., 2022). On the demand side, several studies have shown that the psychological factor *of food neophobia* appears to be a significant barrier (Dolgopolova et al., 2015; Pagliarini et al., 2022; Stratton et al., 2015). However, studies on Chinese consumers are scarce and have shown inconsistent results (Huang et al., 2019; Siegrist et al., 2015), calling for more empirical evidence. In addition, research has suggested that food consumption decisions depend on cognitive determinants (Verbeke, 2005), health status (Annur et al., 2020; Ballco & Gracia, 2022), lifestyle (Moro et al., 2015; Zanchini et al., 2022) and socio-demographics (Sahrin et al., 2023; Siegrist et al., 2013). These factors have not received as much attention in functional food studies as in general food preference studies. Finally, research on what motivates or hinders Chinese people from consuming functional agricultural products, and in particular functional or fortified rice, is relatively scarce (Annur et al., 2020).

We will consider two streams of factors closely related to consumers' purchase decisions regarding functional rice: rice attributes and food neophobia. In addition, we identify cognitive, lifestyle and health factors that influence consumers' choices through the value they attach to the health benefits that functional rice alternatives offer. We also investigate demographic factors such as age, gender, income, education, and marital status to ascertain their influence.

Food neophobia is an aversion to novel foods, which might serve as a protective mechanism against the risks associated with unfamiliar foods (Sahrin et al., 2023). This trait has been identified as a direct barrier to accepting functional food in numerous empirical studies (Bäckström et al., 2003; Dolgopolova et al., 2015; Pagliarini et al., 2022; Schickenberg et al., 2008). However, to date, there has been limited research regarding its impact on the consumption of functional agricultural products. While two studies on Chinese consumers confirmed such an effect (Ortega et al., 2022; Siegrist et al., 2015), another survey found only an indirect effect of food neophobia on the purchase intention towards functional food (Huang et al., 2019). The latter suggests that consumers with higher levels of food neophobia tend to perceive high prices as an indicator of high quality, thereby moderating the negative impact of price on their purchase intention. Although the few studies in the Chinese context have yielded inconsistent results, by building upon evidence across the world, we hypothesize:

H1: Food neophobia is likely to contribute to a decreased preference for functional rice consumption.

Previous studies have explored whether and how demographic variables are correlated with food neophobia. Typically, older males with lower levels of education and relatively low income are most likely to be food neophobic (Bäckström et al., 2003; Schickenberg et al., 2008; Siegrist et al., 2013; Tuorila et al., 2001). Nevertheless, some researchers have identified insignificant relationships between social-demographic variables and food neophobia (Soucier et al., 2019; Stratton et al., 2015). Most of the studies were conducted in Scandinavian countries, while a more recent study in Asia reveals a stronger tendency towards food neophobia among females compared to males (Sahrin et al., 2023). Again, there are few studies on the demographic determinants of food neophobia in adults in China (Tian & Chen, 2021).

H1a: Differences in food neophobia depend on age, gender, education level, and income.

In terms of measurement, the *Food Neophobia Scale*, initially developed by Pliner & Hobden (1992), has been adopted in numerous studies, although some have made modifications to the original version to better serve their specific research contexts (Huang et al., 2019; Ritchey et al., 2003; Siegrist et al., 2013). Whether the modified or the original version is appropriate in each context can be determined by the Cronbach's α value. An α-value of 0.7 or higher indicates a reliable measurement (Damsbo-Svendsen et al., 2017).

2.1. Health benefits

As a component of food labelling and marketing communications, health claims attempt to influence consumer behaviour towards healthy foods (Maeda-Yamamoto, 2017). As food is a vital source of nutrition, an increase in nutritional value leads to a rise in its overall value *ceteris paribus*. Empirical studies have revealed preferences for agricultural products with additional health benefits, such as omega-3-enriched beef (Boncinelli et al., 2021) and probiotic milk (Oliveira et al., 2016). In the case of folate-biofortified rice, even in the context of resistance to technology innovation in crop production, such as genetic modification, the negative attitude can be compensated by the perceived health benefits if the health information is appropriately explained (De Steur et al., 2012). With a growing focus on healthy food, some empirical evidence suggests that the health benefits of functional rice have become a primary motivation for its consumption in China (Yang et al., 2021). Therefore, we hypothesize:

H2: Health benefits are positively related to rice choice.

As the functional agricultural product industry is still in its infancy, the effectiveness of communications about the health benefits of functional rice may be related to a prior understanding of the concept. However, academia has yet to agree on how prior knowledge influences the acceptance of functional foods (Topolska et al., 2021; Verbeke, 2005). Even if the concept is explained, it is likely that consumers' cognitive ability, which relates to the information processing speed (Donders, 1969), may influence their concern about the health benefits. Individuals with higher cognitive ability can quickly absorb the information to make proper choices. The attractiveness of health benefits may diminish if the health claims cannot be comprehensively processed (Oliveira et al., 2016). Therefore, we hypothesize:

H2a: Individuals who spend a shorter time comprehending the definition of functional agricultural products will appreciate the health benefits more than others.

Previous studies have identified a partial influence of lifestyle on consumers' choices regarding functional foods (Zanchini et al., 2022). Research has linked health consciousness with the extent to which consumers value the health benefits of these foods (Ballco & Gracia, 2022). Individuals who lead a healthy lifestyle characterized by regular exercise and consistent sleep patterns tend to pay greater attention to the health aspects of their food consumption (Chammas et al., 2019; Huang et al., 2019). Moro et al. (2015) found that consumers striving to lose weight or maintain fitness are more inclined to pay extra for yoghurt enriched with catechins. Conversely, Goetzke & Spiller (2014) observed that German consumers with less active lifestyles were likelier to purchase functional foods. This trend may stem from the belief among these consumers that consuming functional foods is an easy way to maintain health, especially in the context of a busy lifestyle (Barauskaite et al., 2018). Further, the impact of health benefits on the acceptance of functional rice is likely contingent upon the consumer's health status. Those who perceive themselves as having poor health or an illness tend to be more inclined towards functional alternatives (Ballco & Gracia, 2022).

H2b: Observed differences in the perceived value of health benefits in functional rice can be attributed to cognitive, lifestyle and health-related variables.

The existing literature needs to address the preferences of different types of health benefits. Anecdotal evidence suggests that nutrient-enhanced varieties are more likely to be accepted than low-GI ones. Several studies on biofortified agricultural products have reported a positive correlation between consumers' utility and the labelling of nutrient enhancement. For instance, urban consumers in China favour selenium-enriched rice rather than conventional rice (T. Zhang et al., 2023). Meanwhile, low-GI rice is not always preferred; for example, jasmine rice was preferred over low-GI grains in a study conducted in the Australian context (Gondal et al., 2021).

Regarding low-gluten rice, research on consumer preferences for this type of rice is scarce. Following a gluten-free diet (Silvester et al., 2016; Xhakollari et al., 2019) may suggest a similar preference for low-gluten rice. However, based on this trend, we cannot make a formal hypothesis about low-gluten rice.

H2c: Consumers prefer micronutrient-enhanced rice to other types of functional rice.

2.2. Other attributes of rice

Given the significant cultural influences on rice preferences, studies conducted on Chinese consumers have been the primary source of information on other attributes that potentially influence purchase decisions about functional rice. While some studies suggest organic certification is desirable (Liu et al., 2017; Liu et al., 2023), an experiment on packed rice shows that organic labelling results in disutility (Z. Zhang et al., 2023). In addition, consumers rely on brand (Liu et al., 2017; Nie et al., 2018) and occasionally price (Huang et al., 2019) to gauge the unobservable quality of functional food. Nie et al. (2018) indicate that food quality incidents prompt consumers to emphasise brand reputation more. There is now plenty of evidence about the significance of other observable features, including packaging, shape, and colour (Abukari et al., 2022; Amestoso et al., 2019; Bairagi et al., 2019; Timpanaro et al., 2020). While some findings may not directly apply to the Chinese context, they all contributed to developing a more comprehensive choice experiment in our pilot studies.

H3: Organic certification, brand, packaging, shape, and colour (or whiteness) are attributes that significantly influence consumers' choice of rice.

3. Econometric Foundations

3.1 Discrete choice modelling

In this paper, we model consumer choices as selections among a set of products, each characterized by a bundle of attributes (Lancaster, 1966). We assume that individuals (n) make trade-offs among these attributes within and between alternatives, following the random utility maximising behaviour (McFadden, 1986). Under this paradigm, the utility of each alternative (U_{in}) is a function of its attributes (X_{ki}) and the characteristics of the individual (SE_n); however, as only some attributes can be observed, we estimate a *systematic* utility function (V_{in}) and add stochastic errors $\varepsilon_{in} \sim N(0, \sigma^2)$ to explain

potential inconsistencies (to the modeller, an observer) in choices:

$$U_{in} = V_{in} + \varepsilon_{in} \quad (1)$$

In the simplest possible case – the Multinomial Logit (MNL) model – which assumes that alternatives are independent and homoscedastic, the probability of choosing alternative i is given by:

$$P_{in} = \frac{\exp(V_{in})}{\sum_j \exp(V_{jn})} \quad (2)$$

One specification of the Mixed Logit (ML) model (Train, 2009) extends the simple MNL model by allowing for random parameters. In this case, the utility of respondent n choosing alternative i in a choice scenario t is:

$$U_{int} = \sum_{k=1}^{K} \beta_{kn} X_{iknt} + \epsilon_{int} \quad (3)$$

where β_{kn} are individual parameters representing the marginal utilities for each attribute. An alternative formulation is the error components specification, where the parameters β are fixed for all individuals (as in the MNL) but extra error terms, μ_{int}, are incorporated. These error components are typically normally distributed with a variance to be estimated, capturing correlation among alternatives (Williams, 1977) and *panel effects* across choice scenarios (Hess et al., 2008).

3.2 Latent variables and hybrid choice modelling

A Hybrid Choice Model (HCM), as in this study, incorporates an error component, $\mu_{int} \sim N(0, \sigma_{panel})$, to treat the *pseudo panel effect* inherent to stated choice data. It may also incorporate another error component, $\nu_{int} \sim N(0, \sigma_{corr})$, to consider the potential correlation among certain alternatives (in our case the conventional rice alternatives). Additionally, the HCM allows to extend the analysis by incorporating latent variables, which is very useful when the choice decision involves factors that are not easily accountable, such as attitudes and perceptions (Bamonde-Birke et al., 2017). In this study, food neophobia (FN) is considered a latent variable, with λ a coefficient to be estimated, yielding the following HCM utility function:

$$U_{int} = \sum_{k=1}^{K} \beta_k X_{ikt} + \lambda FN_n + \upsilon_{int} + \mu_{int} + \epsilon_{int} \quad (4)$$

To incorporate latent variables into an HCM we need a Multiple Indicator-Multiple Cause (MIMIC) model with two components (Bollen, 1989): measurement equations and structural equation.

Measurement equations

The measurement equations in the MIMIC model include a set of indicators (Ortúzar & Willumsen, 2024, Chapter 8) that are hypothesized to be explained by the latent constructs. In this study, the indicators were derived from the statements from the *Food*

Neophobia Scale (FNS). Respondents provided answers to those statement on a 1-7 ordinal scale, representing 7 degrees of agreement. Therefore, the likelihood of each degree to be chosen wase specified with an Ordered Logit Model (Daly et al., 2012):

$$LL_{I_{nr},ordered}(\tau,\zeta,FN_n)=\prod_{r=1}^{R}\left[\sum_{s=1}^{7}\frac{\exp\left(\tau_{r,s}-\zeta_r FN_n\right)}{1+\exp\left(\tau_{r,s}-\zeta_r FN_n\right)}-\frac{\exp\left(\tau_{r,s-1}-\zeta_r FN_n\right)}{1+\exp\left(\tau_{r,s-1}-\zeta_r FN_n\right)}\right]$$

where I_{nr} are the respondents' ratings of agreement to the statement r; τ_r are threshold parameters, defining the boundaries between the response categories, and ζ_r represents the impact of FN on the response to statement r.

Structural equations

In addition, the latent variable is usually explained through socioeconomic characteristics of the respondents:

$$FN_n=\sum_{m=1}^{M}\gamma_m Z_{nm}+\eta_n \tag{5}$$

where Z_{nm} stands for the mth socioeconomic variable for the nth respondent, γ_m are parameters capturing the impact of these variables on the latent variable, and the random disturbance η_n distributes standard Normal with mean zero, i.e., $\eta_n \sim N(0,1)$.

4. Methodology

4.1 Survey

We employed the panel service provided by wjx.com, a leading survey company in China, to recruit a diverse sample of respondents across the country. All respondents were informed about the purpose of the research and the privacy policy at the outset of the study. They were also required to sign a consent form prior to participating in the survey. The final sample of 1,666 respondents was collected in July 2023; Table 1 summarises their main socioeconomic features.

Table 1. Summary of demographic information

	Sample Characteristics
Number of observations	1666
Gender	
Female (%)	58.04
Male (%)	41.96
Age	
18-28 (%)	28.93
29-39 (%)	39.80
40-50 (%)	26.05
Above 50 (%)	5.22
Education	
High school or below (%)	11.64
College or bachelor's degree (%)	76.83
Master's degree (%)	10.92
PhD degree (%)	0.60
Annual household income (Currency: CNY)	
Less than 50,000 (%)	4.38
50,000-100,000 (%)	16.09
100,001-200,000 (%)	28.75
200,001-300,000 (%)	25.45
300,001-400,000 (%)	14.41
400,001-500,000 (%)	5.82
More than 500,000 (%)	5.10
Familial status	
Single, never married (%)	21.97
Married, no kids (%)	6.66
Married, have kids (%)	70.65
Divorced/widowed, no kids (%)	0.30
Divorced/widowed, have kid (%)	0.42

Respondents were first required to select a set of functional agricultural products (following a definition of the concept) among a list of products shown to them. We assumed that respondents who passed this test understood the concept of *functional agricultural products* better or faster than their peers. Notwithstanding, those who failed the test were given a second chance and directed to a new test, where they needed to pick out an option not necessarily belonging to the category. Respondents who failed this second test were screened out. In terms of understanding the concept of functional agricultural products, 71.13% of respondents demonstrated comprehension and were successful in the initial round of the test while 28.87% initially failed but succeeded in the subsequent round. Respondents were also asked about rice consumption, family size, exercise habits, sleeping patterns, dietary habits, and any diagnosed diseases. Most respondents reported a regular consumption of rice and indicated that they were the primary decision-makers regarding rice purchases for their families (see details in the Online Appendix). These characteristics ensure that their expressed preferences are more representative of typical rice consumers.

On the other hand, over half of the respondents were not satisfied with their sleeping (59.30%) and eating habits (54.14%), although only a small proportion suffered from diseases or illnesses at the time of the survey (the Online Appendix shows the

measurement instruments used for these variables). Among those facing health challenges, digestive diseases were the most prevalent.

At the end of the survey, we asked respondents for comments and suggestions on the innovation of functional rice. We received 675 valid comments (i.e., excluding empty responses or that solely contained the word 'none'). Based on a word frequency analysis provided by wjx.com (Table 2), besides words like ‘rice’ ‘hope’ and ‘functional’, that were filtered out, the word ‘healthy/health’ was the most frequently mentioned (104 times), followed by ‘price’ (97), and ‘(Micro)nutrition/microelement’ (51). We will refer to this data below, when examining some of the results obtained from our models.

Table 2. Word frequency analysis

Word	Frequency	Word	Frequency
Health/Healthy	104	Flavour	19
Price	97	Different/difference	18
(Micro)nutrition/microelement	51	Group	18
Advertise	33	Enhance(d)	18
Safe(ty)	27	Extension	15
Organic	24	Disease	15
Product effect	22	Accessible/affordable	13
Benefit	21	Green	13

Words filtered out: rice, no/none, hope, functional, develop, can, improve, increase, suggest, body, better, more, ensure, cultivate, research, targeting, product, best, reduce, demand, proper, enlarge, comparatively, produce.

Measuring food neophobia

The aversion towards novel foods is usually measured using the *Food Neophobia Scale* (FNS) proposed by Pliner & Hobden (1992). The original instrument comprised five negative and five positive items. However, since one of the positive items—"I like to try new ethnic restaurants”—was less relevant to our study, we included only the remaining nine items as shown in Table 3.

Table 3. Items of Food Neophobia Scale

Name	Items	
Constantly sampling new foods	I am constantly sampling new and different foods.	(-)
Do not trust new foods	I don’t trust new foods.	
If not known/I will not try	If I don’t know what a variety of food is (i.e., nutrition facts, production process), I won’t try it.	
Like foods from different origins	I like foods from different origins.	(-)
New variety too weird to eat	New variety is too weird to eat.	
If offered new I would try	If someone offered me new varieties of food at dinner parties, I would try.	(-)
Afraid to eat new foods	I am afraid to eat things I have never had before.	
Very particular about foods	I am very particular about the foods I eat.	
Will eat almost anything	I will eat almost anything.	(-)

(-) Scores were reversed for these items. The Chinese translation can be found in the Online Appendix

Respondents completed the survey by expressing their level of agreement with each item on a 7-point Likert scale, where a higher score indicated a stronger aversion to novel foods (i.e., 1 represents ‘very neophiliac’ and 7 represents ‘very neophobic’). The food neophobia measure was internally validated by a high-scale reliability coefficient

(Cronbach's α = 0.81).

The distribution of average food neophobia scores (see Table 4) indicates a moderately high willingness to try novel foods. Most respondents fell within the category of "somewhat neophiliac" and "neither neophiliac nor neophobic". None of the respondents exhibited a complete rejection of new foods, as indicated by the absence of the highest possible score (7) on the average degree of neophobia. However, four respondents scored the minimum (1), indicating an extreme level of food neophilia.

Table 4. Summary of FNS

No.	Items	Mean Score±SD
1	I am constantly sampling new and different varieties of food (-)	2.89±1.15
2	I don't trust new varieties	3.71±1.44
3	If I don't know what a variety of food is (i.e., nutrition facts, production process), I won't try it	3.88±1.53
4	I like foods from different origins (-)	2.92±1.32
5	New variety is too weird to eat	3.14±1.43
6	If someone offers me new varieties of food at dinner parties, I will try (-)	2.69±1.12
7	I am afraid to eat things I have never had before	3.08±1.48
8	I am very particular about the foods I eat	3.45±1.52
9	I will eat almost anything (-)	3.54±1.61
	Average degree of neophobia	3.26±0.89

4.2 Choice experiment

We designed a stated choice (SC) experiment where respondents had to consider four alternatives in every choice task: two types of functional rice, one conventional rice, and a non-purchase option. The addition of a non-purchase option (NPO) is essential in choice experiments that are not pivoted on the respondent's revealed preference alternative. Olsen & Swait (1998) show that not including an NPO in this case may trigger a different choice response mechanism leading to biased estimates (see also De Shazo et al., 2009). Further, adding an NPO increases the realism of the experiment and enhance prediction accuracy (Vermeulen et al., 2008).

Based on the relevant literature, interviews with several rice scientists and consumers, as well as two pilot studies, the rice alternatives were characterised by five attributes: whiteness (colour), organic, brand, health benefit, and price, with the levels shown in Table 5. The complete questionnaire can be found in the Online Appendix.

Table 5. Choice Experiment Attributes and Levels

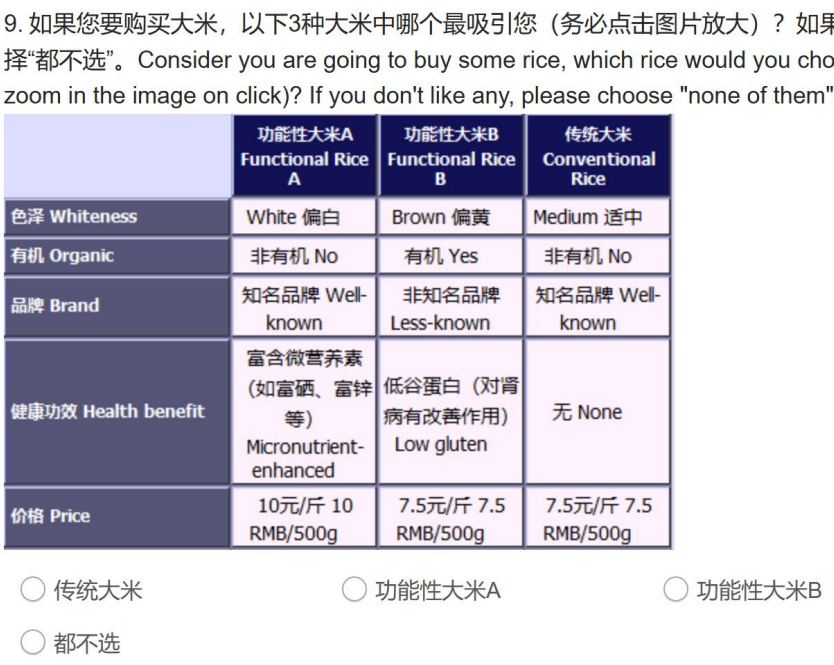
Attribute	Base	Level 1	Level 2	Level 3
Whiteness	Medium	White	Brown	
Organic	No	Yes		
Brand	Less-known	Well-known		
Health benefit	None	Low GI (*beneficial for diabetes patients*)	Low Gluten (*beneficial for patients of kidney diseases*)	Micronutrient-enhanced (*e.g. rich in zinc and selenium*)
Price per 500g	5 RMB	7.5 RMB	10 RMB	15 RMB

Functional rice can be classified into five categories (Liu et al., 2021): high resistant starch rice (or low-GI rice), low-gluten rice, micronutrient-enhanced rice, coloured rice, and drug-manufacturing bioreactor rice. Because coloured rice differs significantly from conventional rice in appearance and as drug-manufacturing bioreactor rice is not available for direct consumption, our study included only the first three types and used “none” (for conventional rice) as levels of the attribute *Health Benefit*. In case respondents were not familiar with this terminology, short descriptions were given in every choice task.

The attribute *whiteness* was carefully selected to overcome perceptual variations among respondents. We defined three distinct colour levels: white, brown, and medium (the latter as the colour falling between white and brown), each representing different levels of rice processing and quality perceptions. The medium colour corresponds to the natural colour of non-polished rice that has been processed in a standard way in many Asian markets, including China.

In terms of the attribute *price*, the functional rice alternatives, with a ´health premium’, should never be as cheap as the base level, to increase realism. Notwithstanding, conventional rice, which could be organic or from a well-known brand, was allowed to vary across all four price levels to capture the full range of consumer sensitivity to price changes. Finally, in China, consumers typically inquire about the cost of products per 500 grams (Jin) when shopping for groceries. To align with this practice and make the survey more relatable, we presented *price* in the same manner.

We used Ngene to generate a D-efficient design (Rose et al., 2008) with two blocks, using priors that were updated through two pilot studies with a total of 81 respondents (the first involved 25 and the second 56 respondents); the D-error of our final design was 0.115298. Each respondent was randomly assigned to one of the blocks and was required to answer the 12 choice tasks in it (see Figure 1 for a sample choice scenario). Other parts of the questionnaire were the same for all respondents.



* 9. 如果您要购买大米，以下3种大米中哪个最吸引您（务必点击图片放大）？如果没有，请选择“都不选”。Consider you are going to buy some rice, which rice would you choose (must zoom in the image on click)? If you don't like any, please choose "none of them".

	功能性大米A Functional Rice A	功能性大米B Functional Rice B	传统大米 Conventional Rice
色泽 Whiteness	White 偏白	Brown 偏黄	Medium 适中
有机 Organic	非有机 No	有机 Yes	非有机 No
品牌 Brand	知名品牌 Well-known	非知名品牌 Less-known	知名品牌 Well-known
健康功效 Health benefit	富含微营养素（如富硒、富锌等） Micronutrient-enhanced	低谷蛋白（对肾病有改善作用） Low gluten	无 None
价格 Price	10元/斤 10 RMB/500g	7.5元/斤 7.5 RMB/500g	7.5元/斤 7.5 RMB/500g

Figure 1. Example of choice scenario in the experiment

4.3 Hybrid choice model with error components

Methodologically, earlier works on this subject have used attitudinal surveys (Urala & Lähteenmäki, 2007), conjoint analysis (Annunziata & Vecchio, 2013), and face-to-face interviews (Küster-Boluda & Vidal-Capilla, 2017).

More recently, a growing number of studies have used stated choice experiments and quantitatively analysed the variables explaining the probability of choosing functional alternatives in hypothetical markets. Most of these studies have adopted Mixed Logit (ML) models (Bairagi et al., 2019; Tian et al., 2022; Yang et al., 2021). However, while useful, ML models cannot adequately account for the potential impact of unobservable psychological elements, such as food neophobia.

To address this issue, we formulated and estimated a Hybrid Choice Model (HCM), which allowed us to integrate both observable attributes and an underlying psychological construct, deepening our understanding of how it affects Chinese consumers' purchase decisions regarding functional rice. As mentioned before, the inclusion of error components allowed us to test for the potential correlation among the two functional rice alternatives (see Figure 1), and also to correctly treat the pseudo-panel nature of the stated choice data (Ortúzar & Willumsen, 2024, Chapter 8). Finally, the model also incorporated several parameters to capture systematic taste variations among respondents (by interacting attributes with socioeconomic data and other characteristics). Therefore, the choice experiment allowed us not only to elicit potential consumer preferences for various aspects of functional rice, but also to capture the influence of an inherently latent factor, food neophobia.

The conventional rice alternative was taken as reference, with a specific constant (ASC) equal to zero, and the latent variable was incorporated into this alternative. Therefore,

if food neophobia is one of the reasons that consumers hesitate to consume functional rice, the parameter λ in equation (4) should be significantly positive. The functional rice alternatives also had an ASC to be estimated, and the utility function of the non-purchase option (NPO) only contained an ASC in its specification. To examine heterogeneity in consumer preferences, we created $J-1$ dummy variables from categorial variables containing J levels. For example, to learn the value respondents attached to different types of functional rice, three dummy variables were generated from the attribute *Health Benefit*. The variable *Low GI* takes the value of 1 for the rice alternative with low-GI and 0 otherwise. Similar rules apply to the other two dummy variables shown below.

The Influence of various factors on the respondents' preferences for and trust in health claims is a complex phenomenon. These factors include, but are not limited to the following: (i) whether the respondent understands the concept of functional agricultural products better and faster than others, as captured by the variable *Better Understand* (with values of 1 indicating success in the first round of concept test and 0 indicating failure in the first round but success in the second chance; note that respondents failing both attempts were excluded from the experiment); (ii) the respondents' lifestyle (captured by the variables *Exercise Habits*, *Sleeping Habits*, and *Eating Habits*, with values of 0 indicating poor habits, 1 indicating not so poor habits, and 2 indicating good habits), and (iii) the respondents' health status (captured by the variable *No Disease*, with values of 0 indicating the presence of a diagnosed disease and 1 indicating the absence of a diagnosed disease. Further, we delved into specific health indicators including *High Blood Sugar*, *Kidney Disease*, and *Family History* of diseases, which were assessed via self-reports by the respondents.

We also considered *Family Size*, a numerical variable that was defined as the number of members in the respondent's family, ranging from 1 to 7 (i.e. *Family Size*=7 indicates a family of seven members or more). Finally, we also considered interactions between *Health Benefit* and some of the above attributes in our analysis. As the respondents' health status and their general health perception may influence their preference for and trust in health claims (Plasek & Temesi, 2019), we considered potential interactions with these attributes. In particular, the dummy variable *Health Benefit* takes the value of 1 if the alternative has any health benefits (functional rice) and 0 otherwise (conventional rice). During our specification searches, the HCM was improved by removing insignificant interactions and updating the starting values.

Figure 2 illustrates the structure of the model. We used the R package Apollo (Hess & Palma, 2019) to estimate the model using simulated maximum likelihood (Train, 2009). The estimated parameters were used to calculate the probability of choosing each alternative for different segments of consumers.

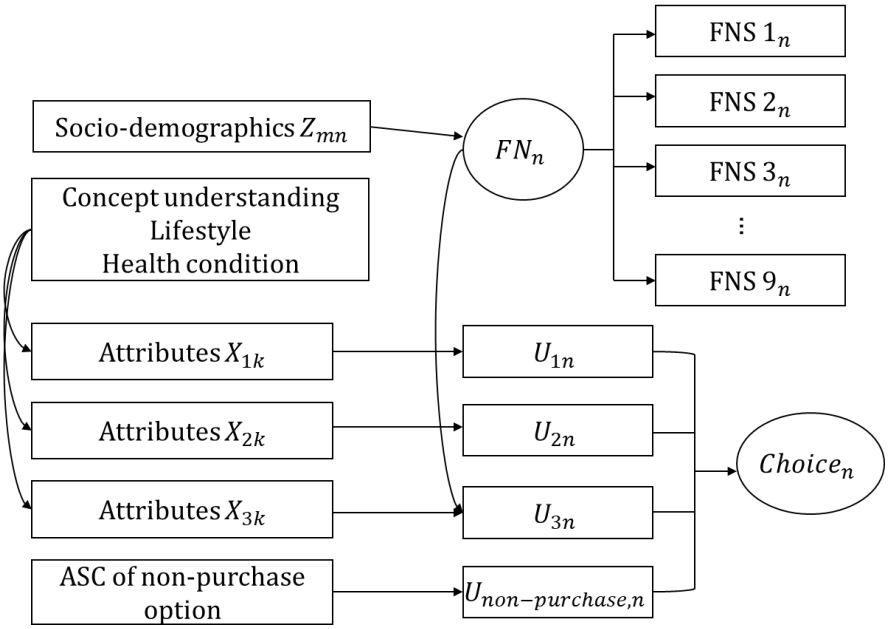


Figure 2. Structure of the HCM-EC model

5. Results and Discussion

5.1 Estimation results

Table 6 shows the main results of the HCM-EC model component. Three comments must be made at the start. First, the ASC of the functional rice alternatives was not significantly different from zero (i.e., not significantly different from the reference alternative), and for this reason it was removed and the model re-estimated. Second, the error component associated with the potential correlation among the two functional rice alternatives was also not significantly different from zero and removed from the model. Third, the signs of all the estimates are consistent with our expectations.

Table 6. HCM-EC discrete choice model results

Attribute	Parameter	Estimate	Rob. t-ratio
	ASC_non-purchase	-1.60***	-15.74
	Medium (reference)	-	-
Whiteness	White	-0.08***	-3.53
	Brown	-0.21***	-9.57
Organic	Not organic (reference)	-	-
	Organic	0.70***	23.72
	Less-known (reference)	-	-
Brand	Well-known	0.17***	6.57
	Younger (age<40) × Well-known	0.15***	2.83
	Conventional rice (reference)	-	-
	Low GI	0	-
Low GI	Younger (age<40) × Low GI	0.25**	2.34
	High Blood Sugar × Low GI	0.47***	3.55
	Edu × Low GI	0.44***	4.71
	Conventional rice (reference)	-	-
	Low Gluten	0	-
Low Gluten	Younger (age<40) × Low Gluten	0.33***	3.17
	Kidney Disease × Low Gluten	1.01***	5.02
	Edu × Low Gluten	0.30***	3.24
	Conventional rice (reference)	-	-
	Micronutrient-enhanced	0	-
Micronutrient-enhanced	Younger (age<40) × Micronutrient-enh	0.39***	3.73
	Edu × Micronutrient-enhanced	0.58***	5.86
	Richer (annual household income > 200,000 CNY) × Micronutrient-enh	0.20***	2.90
	Price	-0.07***	-15.48
Price per 500g	Regular rice consumer (time for family to finish 10kg rice bag <6 months) × Price	-0.01*	-1.73
	Conventional rice (reference)	-	-
	Better Understand × Health Benefit	0.26***	2.59
Health Benefit (contains any one of the health benefits) interactions	Exercise Very Often × Health Benefit	0.11***	3.95
	No Disease × Health Benefit	-0.46***	-4.72
	Better Sleeping Habit × Health Benefit	0.25	1.53
	Family Size × Health Benefit	0.09**	2.55
	Family History of Disease×Health Ben	0.23	1.36
Food Neophobia		0.38***	6.78
Sigma_panel		-1.00***	-17.25
	Log likelihood (0)	-56891.77	
Goodness of fit	Log likelihood (final)	-44374.08	
	ρ^2	0.22	
	Number of respondents	1666	

***p<0.01, **p<0.05, *p<0.1.

All parameters are statistically significant above the 95% confidence level (the critical t-statistic is 1.64 for a one-sided test), except for the parameters of two interactions: Better *Sleeping Habit* × *Health Benefit* and *Family History of Disease* × *Health Benefit*, which are only significant near the 90% level. The high significance of the panel effect variance confirms a strong correlation among the various responses of each individual. In what follows we analyse these results in depth and examine whether they allow to confirm or reject our hypotheses.

The proportion of consumers who selected either type of functional rice (A or B) was 77.15%, which is considerably higher than the proportion who selected the conventional alternative (15.52%). This implies an overall preference for functional rice over conventional rice.

The role of food neophobia

The significantly positive parameter of *Food Neophobia*, which appears in the utility function of the conventional rice alternative, suggests that individuals with higher food neophobia are associated with increased preferences for conventional rice. Therefore, **H1** is supported, and we can confirm that food neophobia plays a substantial role in decreasing the acceptance of functional rice (Chammas et al., 2019).

Further, Table 7 presents the MIMIC model results, which show the influence of various demographic variables on food neophobia (**H1a**). Having children, being younger and richer, emerge as significant negative predictors. This aligns with previous findings suggesting that individuals over 55 demonstrate heightened reluctance towards trying new foods (van den Heuvel et al., 2019). It has also been found in the literature that higher income and education levels may be associated with greater exposure to diverse foods and cultures, enhanced nutritional knowledge, and increased openness to new experiences (Hazley et al., 2022).

Additionally, a lower frequency of rice consumption and being female are associated with higher neophobia levels, although the former does not reach the conventional levels of statistical significance (e.g., $p < 0.1$). However, the effect of gender has not been consistent across studies. Most European research indicates higher neophobia among men (Bäckström et al., 2003; Siegrist et al., 2013; Tuorila et al., 2001), but studies in Asia report either the opposite trend (Sahrin et al., 2023) or an insignificant gender effect (Tian & Chen, 2021), pointing to the influence of cultural factors.

Preferences for health benefits

Hypothesis **H2** is generally supported. The positive coefficients of interactions involving *Low GI*, *Low Gluten,* and *Micronutrient-enhanced* in Table 6 suggest that certain groups of consumers tend to prefer rice alternatives providing health benefits. In follow-up questions asked after the choice tasks, 85.23% of respondents reported that they had paid special attention to the attribute *Health Benefit* when making their choices. This percentage was the highest among all attributes. The word “health” was also frequently mentioned in the open-ended comments at the end of the questionnaire (see Table 2), providing further evidence of its significance in shaping consumers’ perspectives.

Table 7. HCM-EC MIMIC model results

	Variable type	Estimate	Rob. t-ratio
Parameters γ:			
Regular rice consumer (time for family to finish 10kg rice bag <6 months)	Binary	-0.09	-1.19
Younger (age<40)	Binary	-0.23***	-3.31
Education	Numerical	-0.08	-1.33
Have children	Binary	-0.28***	-4.06
Richer (annual household income>200,000 CNY)	Binary	-0.39***	-6.18
Female	Binary	0.13**	2.21
Parameters ζ:			
Constantly sampling new foods	Numerical	1.45***	18.06
Do not trust new foods	Numerical	2.15***	21.74
If not known/I will not try	Numerical	1.68***	21.74
Like foods from different origins	Numerical	1.01***	16.21
New variety too weird to eat	Numerical	1.88***	19.80
If offered new I would try	Numerical	1.07***	15.36
Afraid to eat new foods	Numerical	1.98***	19.83
Very particular about foods	Numerical	0.72***	12.34
Will eat almost anything	Numerical	0.77***	12.41

***p<0.01, **p<0.05, *p<0.1.

Cognitive, lifestyle, health status and demographic factors can significantly influence an individual's valuation of health benefits when making choice over rice. The cognitive ability to understand the concept of functional agricultural products, some lifestyle variables, and health status have an indirect impact on the choice of rice through the attribute *Health Benefit* (**H2a**). Note that in the interaction terms, *Health Benefit* has only two levels: 1 represents functional rice alternatives that offer additional health benefits, which could be any of the three types of health benefits; 0 represents conventional rice without any additional health claims. Those who understood the concept of functional agricultural products faster and better, tended to care more about obtaining the health benefits of consuming rice. A large proportion of respondents (75.67%) who had heard of and consumed functional rice before the experiment, were able to successfully pass the testing question in the first round. This percentage is higher than that of respondents who had heard of but had never tried functional rice (70.64%) or those who had never heard of it (67.07%). It appears then that prior knowledge or experience helps consumers to better understand functional rice and attach more importance to the health benefits of rice.

Among the lifestyle variables, only the habit of exercising very often significantly influences consumers' perceptions about health benefits. This is consistent with previous findings showing that concerns for health benefits increase with the frequency of exercise (Chammas et al., 2019; Moro et al., 2015). However, no matter how good

their sleeping habits are, consumers' attitudes toward health benefits do not significantly change, *ceteris paribus*. Although previous findings suggest that consumers would like to gain health benefits from consuming functional foods without improving their lifestyle, especially eating habits (Barauskaite et al., 2018; Goetzke & Spiller, 2014), this was not the case in our experiment. Additionally, a larger family size also motivates people to be more health-conscious when choosing rice. This could be attributed to the increased responsibility and awareness of health issues within larger families, leading to a more proactive approach in selecting foods with health benefits.

In line with Ballco & Gracia (2022), our results show that health status has an impact on the consumers' valuation of health benefits. Respondents with no disease might feel less relevance and not pay as much attention to this attribute as those who suffered from a disease, while 39.93% of those who stated their concern for health benefits had diagnosed diseases.

Finally, in addition to confirming the notion that health benefits are important in motivating consumers to choose functional varieties, as suggested by previous studies (Chammas et al., 2019; Yang et al., 2021), we further investigated the preferences for different types of health benefits and considered how suffering specific diseases influenced consumers' choice on different varieties of functional rice. Younger individuals with high blood sugar levels and a higher degree are more interested in low-GI rice than others, with a total coefficient of 1.16 calculated as: 0.25 for Younger (age<40) × Low GI, plus 0.47 for High Blood Sugar × Low GI, and plus 0.44 for Edu × Low GI. Low gluten rice is favoured by better educated younger people suffering from kidney diseases (coef. = 0.33 + 1.01 + 0.30 = 1.64). Micronutrient-enhanced rice appeals particularly to younger, better-educated, and wealthier consumers (coef. = 0.39 + 0.58 + 0.20 = 1.17). As we hypothesised in **H2b**, for the same group of people (younger and better-educated, have no diagnosed diseases), the coefficient of *Micronutrient-enhanced* was significant and had the highest magnitude (0.39 + 0.58 = 0.97), followed by the coefficient of *Low GI* (0.25 + 0.44 = 0.69); in contrast, *Low Gluten* rice received the lowest coefficient (0.33 + 0.30 = 0.63). These preferences coincide with the major concerns of micronutrient deficiency and obesity prevalent in China.

Preferences for other attributes of rice

Organic certification, brand, and whiteness significantly influence consumers' rice choices (shape and packaging were excluded from our experiment because of their insignificance in the pilot studies), supporting hypothesis **H3**. According to Table 6, *Organic* certification appears to be the most desirable attribute of rice. The parameter of this attribute is significantly positive and higher than any other. In fact, 70.59% of our respondents stated that they paid attention to *Organic* in the choice tasks. Also, among the 675 respondents who provided valid comments in the questionnaire, 24 emphasized their affinity for organic products (see Table 2). This aligns with findings from previous studies involving consumers residing in more developed areas of China (Liu et al., 2017; Liu et al., 2023). Since our sample is geographically diverse, covering all 33 provincial-level administrative divisions in mainland China, it probably suggests a general rise in public consciousness regarding organic farming.

A well-known brand and a low price would attract consumers, but the importance of these attributes is relatively low. With the intensive occurrence of food safety incidents in China, a brand serves as a trustworthy indicator of safety and quality (Mirosa et al., 2021; Nie et al., 2018) rather than price (Huang et al., 2019). This is particularly clear in the case of people under 40, where a well-known brand makes them more confident in their purchase decisions (coef. = 0.17 + 0.15 = 0.32). In fact, 32 out of our 675 commentators explicitly expressed their dislike toward high prices. As a staple food, the price of functional rice is not expected to be much higher than the conventional varieties (Lim et al., 2021). But those who consume rice more frequently are more sensitive to price (coef. = - 0.07 - 0.01 = - 0.08).

Finally, in terms of colour, the medium level is favoured over both white and brown rice. In the comments section, some respondents also emphasized their preference for avoiding rice with unusual colours. Although brown (such as whole grain) and white (such as extra-fine) rice are readily available in the market and differ only slightly in appearance from medium-coloured rice, people probably perceive the medium colour as the most conventional level. This supports the idea that any alteration in colour could decrease consumers' perceived utility (Shan et al., 2018).

Adding to this, the finding is consistent with the cultural context in China. Chinese consumers often gauge rice quality by looking at colour. Their preferences for rice colour are shaped by a combination of environmental concerns, sensory perceptions, and traditional practices (Jeesan & Seo, 2020; Tong et al., 2020). Specifically, in our experiment, medium colour was linked to the natural colour of rice, while white was assumed to be 'whiter than normal', given the specific Chinese terms used in the experiment. In general, Chinese consumers prefer naturally white-coloured rice (which corresponds to the medium colour in our work). Rice that is whiter than the natural colour seems less nutritive, high in GI (Sasaki, 2019) or making customers suspicious that it may contain additives like bleach or optical brightener. In contrast, rice that is relatively browner than usual may appear as hard to digest and less tasty, or even suspicious of having mildew or being too aged. However, it could also be accepted as it is associated with healthier and more environmentally friendly alternatives (Huang et al., 2021).

Robustness check

Our large sample size enabled us to implement a cross-validation for robustness check. We randomly divided the complete sample in two: an *estimation sample* containing 1,111 respondents (approximately 2/3 of the sample) and a *validation sample* with 555 respondents (approximately 1/3). The HCM model was estimated using the estimation sample and then applied to measure the model's direct log-likelihood (LL) on the validation sample (Ortúzar & Willumsen, 2024, Chapter 8). This procedure was implemented twice (e.g. 2-fold cross-validation, see Hess & Palma, 2019), using different samples for estimation and validation, randomly drawn by the Apollo package. The variance in LL between the estimation and validation samples was minimal, with a negligible difference of -0.67% in both pairs, underscoring the accuracy of our model. Furthermore, the parameters estimated from the two estimation samples were not

significantly different to those obtained using the whole sample. In particular, the estimate of the food neophobia coefficient was 0.41 for the estimation samples and 0.38 for the entire sample.

5.2 Segment analysis

Segment analysis reflects how attractive a product is to a segment of consumers, given their heterogeneous preferences and the characteristics of the product. In this analysis, we considered the presence of our four rice alternatives on the market: low-GI, low-gluten, micronutrient-enhanced, and conventional rice. We assumed also that all alternatives were medium-coloured, organic, and from a well-known brand. Finally, while the three functional alternatives were all priced at 10 RMB/500g, the conventional one was considered as cheap as 5 RMB/500g.

Consumers might choose one of the alternatives or none of them. Instead of considering every possible combination of personal traits, we focused on a few important ones: age (below 40 or not), annual household income (higher than 200,000 or not), health status (high blood sugar, kidney disease, other disease, or no disease), and exercise habit (exercise very often or not). Other personal traits were fixed as follows: education level = college or bachelor's degree (which accounts for 76.83% of our sample); rice consuming frequency = time for the family to finish a 10kg bag of rice <6 months (which accounts for 94.60% of our sample); cognitive ability = better understanding (which accounts for 71.13% of our sample); family size = 4 (which has the greatest percentage among all sizes); sleeping habit = better (which accounts for 95.26% of the sample), and food neophobia = 3.26, which is the average score.

Utilities for each alternative (including the non-purchase option, NPO) were calculated for each of the 32 resulting profiles using the model estimates, attribute levels and personal traits. The choice probabilities can be obtained using equation (2).

As summarized in Table 8, most types of consumers exhibit a clear preference for functional rice over both conventional rice and the NPO. If all types of consumers were distributed evenly in the market, micronutrient-enhanced rice emerges as the most popular choice. This suggests prioritizing the development of new rice varieties that offer additional micronutrient, even when faced with a diverse market preference.

Among those who are diagnosed with kidney disease, there is a consistent preference for low gluten rice, commanding also the highest probabilities. In contrast, consumers without this particular health condition are unlikely to choose this type of functional rice. Since low gluten rice satisfies the specific dietary needs of patients with kidney disease, and they are willing to pay a premium as high as 11.71RMB/500g[2], marketing strategies targeting this consumer group could be highly effective.

Older consumers, especially those who have relatively low income and are healthy, are more reluctant to accept functional rice than the younger generation. Holding everything else constant, frequent and infrequent exercisers tend to share the same

[2] The willingness to pay in our model - with a linear in parameters utility function - is simply equal to the coefficient of the considered attribute divided by the coefficient of cost (Daly et al., 2023); in this case we have (1.01 + 0.33 + 0.30)/0.7 = 23.4 RMB/kg.

choice, except in two cases, where older people with no diseases (richer or poor), prefer conventional rice if they do not exercise very often.

Table 8. Choice Probabilities by Different Consumer Profiles

					Choice Probabilities				
Profile	Age	Annual household income	Health status	Exercise habit	Low GI	Low Gluten	Micro Nutrient Enhanced	Conv. Rice	NPO
1	Younger (<40)	Richer (>200k)	High blood sugar	Very often	0.330	0.194	**0.334**	0.134	0.007
2				Not very often	0.325	0.191	**0.328**	0.148	0.008
3			Kidney disease	Very often	0.170	**0.439**	0.275	0.111	0.006
4				Not very often	0.168	**0.433**	0.271	0.122	0.006
5			Other disease	Very often	0.236	0.222	**0.381**	0.153	0.008
6				Not very often	0.231	0.218	**0.374**	0.168	0.009
7			No disease	Very often	0.215	0.203	**0.348**	0.222	0.012
8				Not very often	0.210	0.198	**0.339**	0.241	0.013
9		Poorer (<=200k)	High blood sugar	Very often	**0.352**	0.207	0.291	0.143	0.007
10				Not very often	**0.346**	0.203	0.286	0.157	0.008
11			Kidney disease	Very often	0.179	**0.462**	0.237	0.116	0.006
12				Not very often	0.176	**0.456**	0.233	0.128	0.007
13			Other disease	Very often	0.253	0.238	**0.335**	0.165	0.009
14				Not very often	0.248	0.234	**0.328**	0.180	0.009
15			No disease	Very often	0.230	0.217	**0.304**	0.237	0.012
16				Not very often	0.223	0.210	**0.296**	0.257	0.013
17	Older (>=40)	Richer (>200k)	High blood sugar	Very often	**0.336**	0.183	0.295	0.175	0.011
18				Not very often	**0.329**	0.179	0.289	0.192	0.012
19			Kidney disease	Very often	0.176	**0.420**	0.247	0.147	0.009
20				Not very often	0.173	**0.413**	0.243	0.161	0.010
21			Other disease	Very often	0.240	0.209	**0.338**	0.201	0.012
22				Not very often	0.235	0.204	**0.330**	0.219	0.013
23			No disease	Very often	0.214	0.186	**0.300**	0.283	0.017
24				Not very often	0.207	0.180	0.290	**0.305**	0.018
25		Poorer (<=200k)	High blood sugar	Very often	**0.355**	0.193	0.255	0.185	0.011
26				Not very often	**0.347**	0.189	0.250	0.202	0.012
27			Kidney disease	Very often	0.184	**0.440**	0.212	0.154	0.009
28				Not very often	0.181	**0.432**	0.208	0.169	0.010
29			Other disease	Very often	0.256	0.223	**0.295**	0.214	0.013
30				Not very often	0.249	0.217	**0.287**	0.233	0.014
31			No disease	Very often	0.226	0.197	**0.260**	0.299	0.018
32				Not very often	0.218	0.190	0.251	**0.322**	0.019

To examine the impact of food neophobia, we repeated the analysis reducing its score to the lowest level in our sample, 2.67; this simulates a society that is very curious and receptive to novel foods. In that case, all profiles would quit choosing conventional rice except for No. 32 (i.e. poorer people with no disease who do not exercise very often).

Conversely, in a super conservative population with a food neophobia score of 6.11 (the highest in our sample), the utility of consuming conventional rice would become very high, and most consumers would switch to it; in fact, only younger kidney disease patients would remain loyal to the low gluten option. These changes reflect the significant influence of food neophobia on the consumer preferences for functional rice.

6. Conclusion

We formulated and estimated a flexible hybrid discrete choice model to investigate the influence of food neophobia on rice choice. This is the first study to examine the effect of this psychological factor in the consumption of functional rice. By introducing a latent variable, we were able to successfully capture and explore various elements behind food neophobia. Our empirical findings deepen our understanding of the more significant barriers to accepting functional rice and suggest developing new varieties.

In line with earlier work (Ortega et al., 2022; Siegrist et al., 2015), our research shows that food neophobia directly influences consumer preferences, steering them towards conventional rice and away from both functional rice and the non-purchase option. However, providing consumers with dietary education may mitigate food neophobia, thereby improving their preference for functional rice. The analysis of demographic factors that explain food neophobia suggests that young men with children, higher education levels, and income are more inclined to embrace novel food and, thus, are expected to be a target group for functional rice. These findings have significant implications for the food industry, policymakers, and dietary educators, offering potential strategies to promote the acceptance and consumption of functional rice.

Regarding rice attributes, the health benefits are the most prominent feature distinguishing functional rice from its conventional counterparts, significantly influencing consumers' rice choices. Despite China's currently underdeveloped functional rice market, this finding implies a bright future. Meanwhile, the valuation of health benefits varies across consumers — those who quickly and better understand the concept of functional agricultural products, exercise more often, and suffer from any disease exhibit a higher utility for these. Based on these results, we suggest communicating the concept and the health benefits of functional rice more clearly. In our choice experiment, we expressed the health benefits as gains. However, it is possible that a loss frame, for example, explaining the risk of high blood sugar from consuming conventional rice, would stir anxiety and drive consumers toward low GI rice (Kawachi et al., 2022). Also, given that exercise enthusiasts and patients show greater interest in the health benefits of rice, offering dietary education in fitness centres and medical facilities may heighten interest in functional rice. This approach could assist these consumers in achieving their wellness goals.

In addition to confirming the importance of health benefits in the Chinese context, as suggested by previous studies (De Steur et al., 2012; T. Zhang et al., 2023), we further delved into comparing consumer preferences for different types of health benefits. We found that micronutrient-enhanced rice was the most appealing type for diverse consumer groups. Consumer preferences for specific health benefits aligned with their

health conditions; for example, individuals with high blood sugar levels were more inclined to choose low-GI rice, while low-gluten varieties appeared more attractive for kidney disease patients. Therefore, we suggest prioritising research to develop micronutrient-enhanced rice and develop products that cater to the dietary requirements of consumers with specific health needs.

Our study reveals that consumers prefer medium-coloured, organic rice from a well-known brand. Therefore, it is crucial to maintain the same level of whiteness as conventional rice when developing new varieties. Since an organic certificate and a reputable brand can alleviate hesitancy or doubts regarding functional rice, marketing campaigns could dedicate more effort to applying organic certification and branding.

In summary, this paper offers several contributions: Firstly, we establish that food neophobia directly hampers the acceptance of functional agricultural products, dispelling the notion of an indirect impact. Secondly, we address the dearth of research on food neophobia among adults in China (Tian & Chen, 2021) by exploring various demographic factors associated with this trend. Thirdly, we enhance the understanding of consumer preferences for functional rice in the Chinese context. Specifically, we underscore the pivotal role of health benefits and examine how their valuation varies among consumers with different cognitive, lifestyle, and health condition factors, providing practical insights for product development and marketing strategies. Fourthly, the model in use is a relatively new approach to food preference research. It adds to the methodological toolkit for studying consumer behaviour regarding food consumption. More importantly, constructing latent variables helped to adequately capture the unobservable psychological factors. Finally, building upon the econometric analysis, we provide policy suggestions for developing and marketing functional rice in the Chinese market, which are potentially applicable to other functional agricultural products worldwide.

Our large and diverse sample allowed obtaining robust findings that could be extended to other functional agricultural products. However, the relatively low daily intake of some products, such as seafood and fruit, compared to rice, may mitigate the negative effect of food neophobia. On the other hand, products like ginseng naturally attract health-conscious consumers. Therefore, further empirical studies are needed to explore the factors driving preference from conventional to functional varieties of different agricultural products. This future research holds promise for expanding our understanding of consumer behaviour in the food industry.

Finally, our study underscores the critical role of consumer trust in influencing the acceptance and willingness to pay for functional rice. This finding highlights the need for further research to quantitatively measure the level of consumer confidence and its impact on the demand for functional crops. Additionally, considering the differences in dietary habits between southern and northern Chinese people, further investigation is warranted. Southerners, who consume rice as a staple food, may have different perceptions of functional rice compared to Northerners, who tend to consume more wheat-based meals. Understanding these regional variations is crucial for promoting the acceptance of functional rice across China.

Acknowledgements

The first author is grateful for the sponsorship by Dean's Fund from Ningbo Academy of Agricultural Sciences (Grant Number: 2023NKYP003). The third author is grateful for the support of Instituto Sistemas Complejos de Ingeniería (ISCI), through grant ANID PIA/PUENTE AFB230002.

7. Declarations of interest

None.

8. Data and code Availability

Data and code used for this study can be downloaded from https://data.mendeley.com/datasets/w5bg9bnjcw/1.

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