Information exposure incentivizes consumers to pay a premium for emerging pro-environmental food: Evidence from China

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ABSTRACT

This study aims to reveal Chinese consumers' willingness to pay for Green manure-rice and its determinants by conducting an information intervention experiment. Results first showed that consumers' willingness to pay before and after the information intervention was 7.9 CNY/kg and 12.1CNY/kg, which was 2.6 CNY/kg and 6.8 CNY/kg premium than that of conventional rice, respectively. This finding highlights the necessity of eliminating information asymmetry in the pro-environmental food market through external information supply. Afterwards, the decision mechanism by which consumers pay for Green manure-rice was explored. The main conclusions are as follows. First, both subjective self-evaluation and environmental literacy had a positive and significant impact on consumer premium. This finding provides policymakers with the enlightenment that it is feasible to raise consumer premium by actively guiding their subjective self-evaluation and fostering their environmental literacy. Second, the moderating effect of information intervention on consumer awareness of Green manure-rice attributes was identified. This result not only emphasizes the positive role of food attribute labeling in guiding consumers' payment, but also further verifies the effectiveness of information strategy in promoting the development of Green manure-rice market. Third, information intervention narrowed the gap of payments between different consumer groups, which provides instrumental support for stabilizing the Green manure-rice market. These results are of great importance for both guiding the update of pro-environmental food market and promoting paddy agricultural system innovation in China.

1. Introduction

Over the past few decades, the use of agrochemicals, especially in rice farming, has increased greatly in China. Despite the rapid growth in food production, a series of environmental consequences and food safety concerns have also been arisen. As a response, a regional agricultural renovation scheme covering a wide range of areas, the rice-green manure rotation system (RGRS), has been developed by the Chinese government to mitigate the adverse effects of traditional agriculture. However, due to the high participation costs, farmers' involvement in this practice remains low (Li et al., 2020). Farmers' pro-environmental behaviors (PEBs) in agriculture are likely to be sustainable only if the benefits from their actions are sufficient to cover the production costs and further improve their families' livelihoods (Lapka et al., 2011).

Therefore, discovering the extent to which farmers benefit from participating in RGRS has become the key to evaluate the effectiveness of environmental governance.

Consumers' willingness to pay (WTP) for pro-environmental foods (PEFs) produced by PEBs in agriculture is closely related to farmers' income, which has been demonstrated by studies conducted by White and Brady (2014) and McFaddenJonathan and HuffmanWallace (2017). In general, the higher the price that consumers pay, the greater the profit that farmers get from the PEFs (Kleemann and Thiele, 2015). In some developed economies, there has been growing consumer interest in PEFs over the last decades (Laureti and Benedetti, 2018). Since consumers are generally willing to pay premiums for PEFs (Lusk and Schroeder, 2004), such foods produced by farmers can be matched with higher prices. In developing countries such as China, however, the prices of PEFs are not

always higher than that of conventional foods limited by consumers' lower payment ability (Yu et al., 2014; Wu et al., 2015). As a result, farmers participating in PEBs may not necessarily gain enough benefits to make up the costs, which is extremely detrimental to the sustainability of their behaviors.

Green manure-rice (GMR), the end product of RGRS, emerging as a novel PEF in the rice market of southern China accompanying with the development of the improved agricultural system (CGMRS, 2020). China has nearly 13 million hectares of cultivated land suitable for developing RGRS, and the current output of GMR is still less than 20% of the total production capacity (CGMRS, 2020). From this point, GMR has the potential to dominate the pro-environmental rice market in the near future, which is one of the purposes of selecting GMR as the research object for a priori study. Different from the publicly recognized and highly commercialized PEFs that have been labeled in the market, GMR has just appeared in the market in recent years, and it seems that the existing research has not explored the consumers' WTP of GMR. This research will provide insights for the development of the GMR industry and the path of RGRS promotion by evaluating consumers' WTP.

Developing new market for GMR requires the existence of promising consumer segments who embrace this kind of food, and identifying consumers' WTP and the factors that influence payment is a key part of fostering this new market. A rich literature has emerged exploring consumers' WTP for PEFs using differentiated approaches. These methods can be broadly divided into three categories: the contingent valuation method (CVM) (Huang and Lee, 2014; Alfikri et al., 2019; Yormirzoev et al., 2020), the choice experiment (CE) (Lusk and Schroeder, 2004; Yin et al., 2008; Wu et al., 2016) and the experimental auctions (EA) (Li and Ellis, 2014; Vecchio et al., 2016). Compared to CE and EA, CVM is more commonly used by researchers for its convenience and wide applicability (Horowitz and Mcconnell, 2003; Darla et al., 2010). To be specific, the convenience of CVM is unparalleled (Simpson, 2010; Jin et al., 2018), and regardless of which guiding strategy is used, the consumer's payment response is easily obtained (AI Sanjuán et al., 2012; White and Brady, 2014). More importantly, the CVM approach, although originally designed to assess non-market value, behavioral economists have widely applied the method to the study of consumers' WTP for particular foods (Huang and Lee, 2014; Jia and Ge, 2016). These studies emphasized that the method could not only be used to assess consumers' WTP in mature markets (Gassler et al., 2016), but also had natural advantages in assessing WTP in hypothetical markets or growing markets (Li et al., 2016). Therefore, CVM was finally selected to carry out this study.

Identifying determinants of consumers' WTP can help configure more reasonable price for GMR and remove obstacles to the diffusion of this food. Existing literature has generally paid attention to explain how demographic characteristics affect their payment decisions. These factors usually include: individual information such as respondents' gender, age, schooling, etc. (Chege et al., 2019; Yang et al., 2020), family information such as household size and population structure, income, dietary habit, etc. (Schroeder, 2009; Brown et al., 2010), and various perceptions of the food attributes and the external environment (Gao and Schroeder, 2010). These variables provide simplified representations of the underlying drivers involved in given contexts. However, an important influencing factor, information intervention, is generally ignored in the above studies. As for the novel PEF such as GMR, consumers have little knowledge of it when it first enters the market. At this time, providing consumers with convincing product information may have a significant impact on their WTP (Lange et al., 2003). Therefore, exploring the influence mechanism of information intervention on consumers' WTP should also be an important task of this study.

To sum up, the overall aim of this study was to explore consumers' WTP for GMR and its determinants. Specifically, the answers to the following two questions will be given: (1) how much premium are consumers willing to pay for GMR, (2)what factors will affect consumers' WTP for GMR, and in particular what role does informational intervention play? The current research offers marginal contributions on three major aspects. First, the estimation of consumers' WTP for GMR is helpful to improve the GMR pricing mechanism. Second, the paper provides insights into the determinants of consumers' WTP thereby informing strategies to promote GMR market from a China rural revitalization context. Third, this study contributes to the literature on the effectiveness of market-based economic induction as alternatives to government-led eco-compensation policies in maintaining farmers' PEBs.

The remainder of this paper is organized into seven sections: Section two describes the research background which includes consumer food trends and GMR in China. Section three constructs the research framework and puts forward the research hypothesis through literature review. Section four introduces the study area, survey design, data collection, and research methods. Section five shows the empirical results, and section six discusses the main findings and puts forward the research deficiencies. The final section sums up the research conclusions.

2. Consumer food trends and GMR

2.1. Consumer trends: safety and nutrition

2.1.1. Consumers' pursuit of safe foods
Consumers in developed countries have long been concerned about food safety, and that concern has not abated until now (Young et al., 2015). For example, Huygens et al. (2012) paid attention to the food safety issues of European consumers and pointed out that more than 95% of respondents expressed that they would try to obtain food with high safety grade in their daily life. Charlesworth et al. (2021) investigated Australian consumers awareness of safe food against a backdrop of rising food poisoning incidents and almost all respondents expressed strong concern. Yu et al. (2017) investigated consumers' food safety perceptions of in the United States, and found that the vast majority of consumers, especially millennial generation consumers, paid great attention to food safety. In some developed Asian countries such as South Korea and Japan, consumers are also actively seeking safe food (Smith and Riethmuller, 2000; Lee et al., 2012).

Studies suggest that consumers in developing countries are also increasingly preferring foods produced in safe ways due to concerns about food safety (Yu et al., 2014). Boodhu et al. (2010) indicated that consumers in Trinidad, West Indies generally consider that safe food is "very important". An international survey among consumers in developing countries from Asia and Africa on food safety showed that consumer demand for safe food is growing even in the poorest developing countries (Odeyemi et al., 2018). In China, over the past few decades, the intensive use of chemicals in agriculture has led to the contamination of agricultural products, causing a series of public health incidents (Sun et al., 2017). For instance, vegetables with excessive pesticide residues in Shandong and Hainan in 2010, and poisonous rice in Yunnan in 2020. These incidents have severely eroded consumer confidence in conventional foods and forced them to look for safer and more healthy alternatives. Food safety has emerging as a primary consideration for Chinese consumers when making purchase decisions. Studies of Jian et al. (2011), Ortega et al. (2011), Anne-Célia and Stéphan (2012), Liu et al. (2013) and Shan et al. (2013) have all verified the above assertions. According to the above analysis, a universal phenomenon can be observed, that is, no matter in developed countries or developing countries like China, attention to food safety has become a trend of consumption.

2.1.2. Consumers' pursuit of nutritious foods
Food nutrition is another important aspect of a healthy diet (Wijesinha-Bettoni and Mouillé, 2019). However, due to economic constraints, a significant proportion of the population in developing

economies, especially those deeply trapped in the "hunger trap", currently have limited access to nutritious food (Glover and Poole, 2019). Some studies have also found that consumers in these countries generally lack awareness of nutritious food (Penne and Goedemé, 2021), and they are more inclined to invest their limited income in food purchases that can meet their subsistence needs (Chege et al., 2019; Gillespie et al., 2019).

In developed economies and some rapidly emerging developing economies, consumers pay special attention to the nutritional attributes of food (Drichoutis et al., 2005; Colson, 2011; Ballco et al., 2019; Gurinovic et al., 2020; Yang et al., 2020). In China, the major engine of global growth, the "hunger trap" has been cracked through the efforts of several generations, and dietary nutrition has gradually become a new pursuit of food consumption (Wang et al., 2008; Hong et al., 2021). A survey conducted in 2020 shows that many Chinese urban consumers, in particular those in big cities, are starting to pay attention to food nutrition, with approximately 76% of respondents reporting they are willing to pay for the nutritional attributes. Considering the phenomenon of "fewer births" in urban families in China, parents generally pay special attention to the choice of nutritious foods for their children (Li et al., 2021), which will surely further boost the development and upgrading of the nutritional food market.

2.2. Safety and nutritional attributes of GMR and consumer preferences

2.2.1. GMR production and it's safety and nutrition mechanism

Green manure-foods (GMFs) refer to PEFs grown with green manure as the primary crop fertilizer. Obviously, GMFs are not processed products using green manure as the raw material, but natural products produced from the succeeding crops of green manure crops. Three suitable areas for growing green manure exist in China: the southern paddy field region (SPR), the northern plain dry-land region, and the northwest plateau dry-land region (Li et al., 2020). Compared to the other two regions, the SPR, has more prominent advantages of developing green manure because of the unique climate and farming system (Li et al., 2021). At present, SPR has become the area with the largest green manure coverage in China, and GMR produced by RGRS has also been the most mainstream GMFs in southern China and even the whole country. The production process of GMR is shown in Fig. 1.

The GMR production and certification presents the following characteristics:

● The nutrients needed for the growth of rice crops are mainly provided by green manure crops instead of chemical fertilizers. Nutrient management is regulated by government authorities to ensure that there is no illegal overuse of chemical fertilizers in rice cultivation (CGMRS, 2020).

● The nutritional ingredient and safety index of the products comply with the established standards proposed by the China Green Manure Industry Technology Research and development Center (CGMRS, 2020). Before GMR enters the market, it is necessary to detect the

content of amino acids and harmful substances such as heavy metals (Wang et al., 2022).

As such, the safety and nutrition of GMR can be well guaranteed.

2.2.2. Consumer preferences for GMR

Previous research has found that household income is a major determinant of PEFs consumption (Krystallis and Chryssohoidis, 2005; Batte et al., 2007; Pish Ba Har, 2013; Huang and Lee, 2014). Although China has become the world's second largest economy, its per capita disposable income is still far below the level of developed countries. Consumers' ability to pay premiums for PEFs cannot match that of developed countries. This determines that the relatively cheap PEFs (compared to organic food) may be more popular and have a greater market in China (Mahmood and Khalid, 2021; Lei et al., 2021). GMR is not as expensive to produce as green or organic rice, its price is likely to be at a relatively low level when the market is in equilibrium between supply and demand. Therefore, GMR seems well aligned to current food trends, and consumers in China may be more willing to pay for it (Chekima et al., 2016). In reality, GMR production and consumption have been paid increasing attention in southern China in recent years. In Guangxi province, for example, a batch of GMR production bases have been built, and in Anhui province, a number of GMR brands have been developed. Other provinces such as Hunan, Hubei and Jiangxi, have also issued supportive policies to encourage the development of GMR industry.

3. Research framework and hypotheses

With the aim of developing a comprehensive and explanatory research framework, the AES (Awareness-Environmental literacy-Subjective self evaluation) was referenced at an individual level but added the information intervention to consider the value of information related to the GMR attributes.

3.1. Subjective self-evaluation

In this study, subjective self-evaluation was defined as the self-psychological tradeoff of consumers' concern for food safety and nutrition. Researchers have found some evidence that consumers who are more concerned about food safety or nutrition are more likely to pay premiums for PEFs or food labels. For example, Obayelu (2014) pointed out that consumers' pursuit of better food nutrition made them willing to pay for organic leafy vegetables. Sckokai et al. (2014) showed that consumers who are more concerned about the potential risks of mycotoxins are more willing to pay a premium for the milk obtained by cows fed with maize certified for the "good practices". Liu et al. (2017) found that those who scored higher on the awareness of food safety are more likely to pay for food labels. Studies conducted by Henson (1996) and Fafchamps et al. (2008) also reached consistent conclusions. In fact, expectancy theory provides support for the positive correlation between

Fig. 1. The production process of GMR in SPR.

subjective self-evaluation and individual behavior. According to the theory, positive subjective self-evaluation often brings high psychological expectation, and high psychological expectation helps catalyze expected behavior (Slamet and Nakayasu, 2017). Therefore, it can be wondered that consumers who pay more attention to food safety and nutrition are more willing to pay a higher price for GMR.

Subjective self-evaluation would be identified through two questions which are measured on a 3-point Likert scale (ranging from "disagree" to "agree"): "I'm concerned about food safety/nutrition". A *food safety (Con_fs)* or *food nutrition (Con_fn)* indicator equals 3 if the respondent stated agree. *Subjective self-evaluation* scores are calculated based on a weighted average of the answers to the two questions. The following hypothesis was proposed:

H1. Subjective self-evaluation had a positive influence on consumers' WTP for GMR.

3.2. Environmental literacy

Environmental literacy refers to people's self-consciousness of constantly adjusting their economic activities and social behaviors to protect the environment (Kuruppuarachchi et al., 2021). Consumers' understanding of the issues behind PEFs may be influenced not only by food-specific knowledge, but also by their environmental literacy (Truelove et al., 2014). Thøgersen (2009) proposed the "environmental behavior spillover effect" to explain the influence mechanism of environmental literacy. The connotation of this effect can be described as follows: one environmental behavior is catalyzed by other daily environmental behaviors with the same underlying process in specific context when environmental literacy has reached a certain level. Recent studies have pointed out that some PEBs such as domestic waste classifying, recycling, resource and energy saving, etc. can catalyze the behavior of paying for green food (Johe and Bhullar, 2016; Li et al., 2021a,b). The environmental literacy–in our case–the attempt to encourage consumers to transform their daily PEBs into pro-environmental intention of paying a premium for GMR, was focused on.

For city dwellers, they have more or less adopted pro-environmental practices, either because of environmental awareness or for the sake of saving living costs. To provide a measure of scientific understanding, participants answered four questions related to everyday lifestyle: "The frequency of using biodegradable plastic bags/sorting domestic solid waste/saving water or electricity/donating time or money to environmental organizations". The four items are measured on a 3-point-Likert scale (ranging from "Never" to "Always or often"). *Environmental literacy* scores are calculated based on a weighted average of the answers to the four questions. The following hypothesis was proposed:

H2. Consumers with higher environmental literacy are more likely to pay a premium for GMR.

3.3. Awareness of GMR attributes

PEFs have three attributes of pro-environment, safety and nutrition. In this study, awareness of GMR attributes specifically refers to consumers' understanding and recognition of the above three attributes. As the potential risks of food production and consumption continue to be exposed, there is a growing consumer demand for foods with these characteristics. In this context, consumers are increasingly willing to pay for PEFs as long as the foods are available on market (Laroche et al., 2013). It should be noted that there is an implicit precondition for consumers' paying action, that is, the attributes of PEFs are recognized by the public (Magnusson et al., 2003). This claim has been supported by previous studies. For example, Hai et al. (2013) highlighted that the more consumers are aware of the safety attributes of a PEF, the more they are willing to pay a higher price. Chege et al. (2019) pointed out that positive food nutrition perception would have a positive impact on

consumers' purchasing behavior and payment level. The awareness of food safety and nutritional attributes has become one of the most important determinants of the current emerging food purchase decision (Vanhonacker and Verbeke, 2014; Daniel and Baba, 2016). In addition, Kinnear et al. (1974) showed that consumers' purchasing decisions are not only economically rational, but also ecologically rational. In other words, consumers are more inclined to pay for food produced with PEBs. Accordingly, the following hypothesis was proposed:

H3. The more consumers know about the safety, nutritional and pro-environmental attributes of GMR, the more they are inclined to pay a higher premium.

3.4. Information intervention

Prior studies have found that providing consumers with the necessary information changes their WTP for food products (Li et al., 2004; Chen et al., 2018), including reducing the overestimated WTP (McFadden et al., 2017) and enhancing the underestimated WTP (Clark et al., 2017). In reality, consumers' WTP for emerging foods with specific functions or attributes is unpredictable if there is no information guidance before the formation of the food market (Rousu et al., 2007). This means that consumers may pay more or less than they are worth (Chowdhury et al., 2011). Consumers in advanced economies are generally willing to pay premiums for emerging foods because of their curiosity (Diaz et al., 2012), with the consequence that, they may be over-paying and suffer from a cost of ignorance (Wilson and Lusk, 2020). The provision of information will rectify consumers' previous misperceptions and lower the payment level (Streletskaya et al., 2019). However, researchers have looked at the opposite scenario in developing markets (Wongprawmas and Canavari, 2017; My et al., 2018). They pointed out that the cautious mindset has led consumers to generally underestimate the value of emerging foods, resulting in lower WTP. Under this circumstance, the provision of positive information will strengthen consumer confidence and raise the level of payments (Zhan et al., 2019). Accordingly, the following hypothesis was proposed:

H4. Information intervention increases consumers' WTP for GMR.

Bayesian decision theory assumes that when person is exposed to new information, an updated awareness will be formed by integrating prior awareness and new information, which reveals the influence mechanism of information intervention on consumer WTP (Wilson and Lusk, 2020). Hereby, it can be asserted that consumers' prior awareness of GMR attributes will influence responses to the facts presented in survey. Therefore, the following hypothesis was developed:

H5. Information intervention plays a positive moderating role in the influence of consumer awareness on WTP.

Considering the heterogeneity of the initial state of the individual, information intervention is likely to have a differentiated impact on the decisions of different agents. Numerous studies have supported this view. For example, Skuza et al. (2015) conducted a field experiment to elicit consumers' WTP for organically produced apples, and the results showed that despite receiving the same information, individuals who received compensation were significantly more willing to pay than those who did not receive compensation. Lusk and Fox (2002) found that consumers with lower initial premium for food labels increased the WTP premium more significantly, while those with high initial valuation seemed to respond less sensitively to the information. For PFEs, if consumers' initial WTP is high enough, the value will not increase immoderately due to the limitation of their payment ability even if the information intervention is effective (Janssen and Hamm, 2012). To sum up, it can be expected that:

H6. Compared with consumers with higher initial WTP, information intervention has a greater effect on improving the WTP of consumers with lower initial WTP.

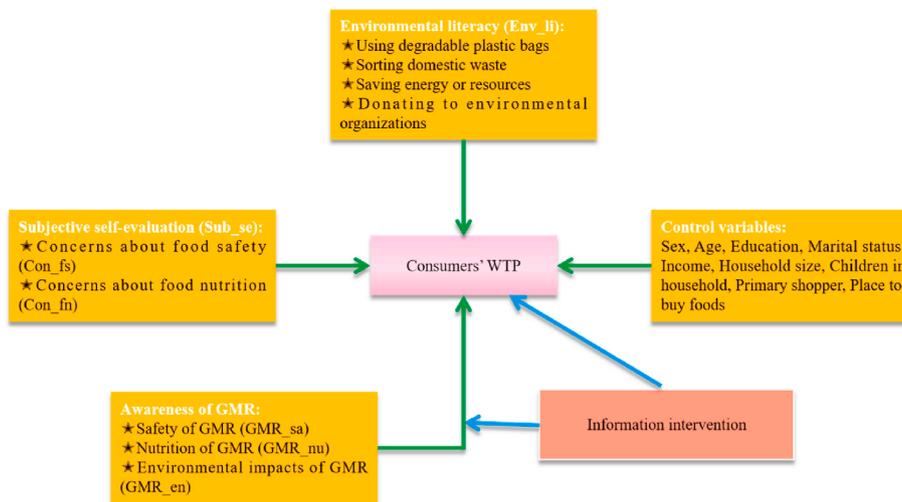Fig. 2 shows the integrated framework of this study.

Fig. 2. The research framework of this study.

4. Materials and methods

4.1. Study area

The official statistical data from CGMRS were used to identify GMR production and consumption among different geographical areas. A regional instead of a nationwide scope was chosen because markets for GMR in China are typically regional markets with respect to the structure of supply and consumption. At present, almost all of the GMR is grown in SPR, with more than 60% of the yields comes from the four provinces of Hunan, Hubei, Jiangxi and Anhui. In fact, these provinces are in the heart of SPR and also is recognized as the region with the most common GMR consumption. Thus, the four provinces were ultimately selected as the representatives in this study. Given that the consumers of GMR are mainly urban residents, especially those in big cities, the provincial capital of Changsha (Hunan province), Wuhan (Hubei province), Nanchang (Jiangxi province) and Hefei (Anhui province) were therefore chosen to conduct our survey. The four provincial capitals are the largest cities in their respective provinces, both in terms of population and economic size. Research on consumers' WTP for GMR in these cities can provide useful information for the formulation of policies related to industrial upgrading and environmental management.

4.2. Survey design

4.2.1. Questionnaire, pilot and information intervention process

The initial questionnaire was structured into five parts. The first part concerns the sociodemographic information of respondents including the gender, age, education level, state of health, family income, family numbers, etc. The second part investigates the respondents' consumption habits. The third part shows consumers' subjective self-evaluation (Concerns about food safety and nutrition). The fourth part investigates consumers' environmental literacy. The fifth part is related to consumers' awareness of GMR attributes, and the GMR purchasing options (intention and behavior) and consumers' WTP. It should be noted that the fifth part of the questionnaire is divided into two sub-parts (V-1 and V-2). A two-stage conditional valuation method was adopted to investigate consumers' awareness and WTP. The specific operation process is as follows (Fig. 3): the first step is to obtain consumers' initial awareness and WTP without any information guidance and these contents were arranged in V-1; the second step is to obtain the updated awareness and WTP after information intervention and these queries were organized in V-2. The information took the form of image and brief text segment (see Appendix A). It should be noted that only some parts of questionnaire were used in this study, and other information will be used in another research.

When the questionnaire design was completed, a professional group was summoned to check the items, and the issues that are not easy to
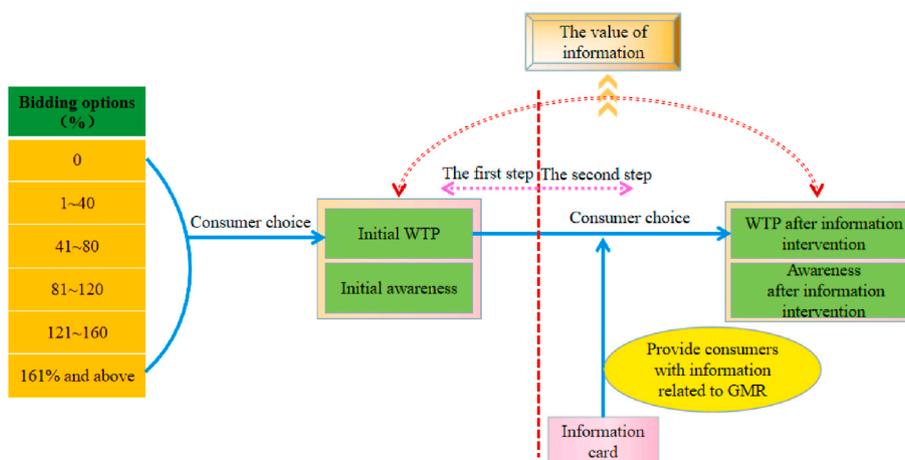

Fig. 3. Information intervention experiment process.

understand were optimized. Furthermore, a pilot survey was conducted in Changsha in November 2019 to test the rationality of the questionnaire. The unreliable items in the original questionnaire were eliminated on the basis of pilot data analysis. The price of conventional rice was set as the benchmark price to investigate the WTP for GMR. The pilot survey results show that the respondents' WTP for GMR is no more than additionally 200% of the price premium of conventional one. Accordingly, the final bidding options of consumers' WTP for GMR was determined: 0 = 0; 1 = 1–40%; 2 = 41–80%; 3 = 81–120%; 4 = 121–160%; 5 = 161% and above. In the end, the official version of the questionnaire which can be used for the formal data collection, was obtained.

4.2.2. Survey and sample characteristics

The questionnaires are in electronic forms. At the end of November 2019, the official version of questionnaire was submitted to the Questionnaire Star, a professional online survey platform maintaining a giant customer of around 6.5 million people in mainland China (Si et al., 2020). To ensure the data quality, screening questions in terms of the residence of respondents were strictly established; furthermore, the paid service of the platform was used to ensure that the respondents who successfully completed the survey were rewarded with a certain amount of money. Note that only consumers at least 18 years old were allowed to participate in the online survey. Additionally, as part of the ethics declaration, each questionnaire also included a contact e-mail at Chinese Academy of Agricultural Sciences (CAAS), so that questions arising from answering could be addressed in time (see Table 1).

The investigative principle proposed by the National Oceanic and Atmospheric Administration (NOAA) was also applied to improve the validity and reliability of the survey results: (1) confidentiality statement: state that the questionnaires are only used for scientific research without involving personal information disclosure; (2) survey process control: layout the questionnaire structure reasonably to ensure that each interview can be completed within 5 min. In the online survey, respondents were considered inattentive and excluded from the sample set if they met one of the following two criteria: (i) spent less than 20% of the average time on the survey, (ii) spent less than 5s on the information card page. As a result, a total of 1025 consumers took part in the survey. However, 52 questionnaires were deemed invalid. Finally, 973 effective questionnaires including 273 from Changsha, 230 from Wuhan, 250 from Nanchang and 220 from Hefei, were obtained. Descriptive statistics of variables used as controls in our study are presented in Table 2. The sample is broadly representative of the Chinese urban consumer by gender, income, and shopping places, however, leans toward a slightly younger and higher educated demographic, which is common in online-based surveys (see Table 3).

4.2.3. Reasonableness of sample size

According to Agidew and Singh (2018), the following formula can be used to calculate the minimum sample size:

Table 1
Abbreviations in this study.

Abbreviations	Explanation
GMR	Green manure-rice
PEB	Pro-environmental behavior
PEF	Pro-environmental food
RGRS	Rice-green manure rotation system
SPR	Southern paddy field region
WTP	Willingness to pay
CVM	Contingent valuation method
CE	Choice experiment
EA	Experimental auction
GMF	Green manure-food
CGMRS	China Green Manure Research System
GMRH	GMR in husk

Table 2
The basic characteristics of the sample.

Variable	Description	Frequency	Ratio (%)
Age	25 years old and below	241	24.77
	26–35 years old	369	37.92
	36–45 years old	224	23.02
	Over 45 years old	139	14.29
Gender	Male	422	43.37
	Female	551	56.63
Highest education completed (Education1)	High school or below	131	13.46
(Education2)	Professional training or bachelor's degree	491	50.46
(Education3)	Master's degree	272	27.95
(Education4)	Doctorate degree	79	8.13
Marital status	1 = Married	604	62.08
Annual household income	100000 CNY and below	488	50.15
	100001 CNY - 200000 CNY	340	34.94
	200001 CNY -300000 CNY	98	10.07
	300001 CNY and above	47	4.84
Household size	Less than 4	368	37.82
	4–5	440	45.22
	More than 5	165	16.96
Children in household	1 = if children under 18 in household	556	57.14
Primary food shopper	1 = if the respondent is the primary shopper in household	625	64.23
The most common place to buy foods	Local market	255	26.21
	Little retailers	128	13.16
	Supermarket	512	52.61
	Online	78	8.02

Note: "CNY" refers to Chinese yuan, 1 CNY = 0.1542 USD (April 26, 2021).

$$n = \frac{N}{1 + N(e)^2} \tag{1}$$

where n represents the sample size; N denotes the total population size (in units of 1000); e is the level of precision (5%). In 2018, the number of urban residents in Changsha, Wuhan, Nanchang and Hefei is 6.45, 8.89, 5.63 and 6.06 million respectively.

Calculations using formula (1) showed that a sample set containing no less than 394 respondents is required in carrying out this study. Obviously, the sample size of the study meets the theoretical requirements.

4.3. Methodology

4.3.1. The contingent valuation method (CVM)

CVM was originally designed to assess non-market values such as environmental services, but several behavioral economists and food marketers have applied this method to estimate consumers' WTP for PEFs by creating a hypothetical market. For instance, Tranter et al. (2009) estimated consumers' WTP for organic conversion-grade food by using the CVM approach in five EU countries. F Salladarré et al. (2016) applied CVM to study French consumers' WTP for eco-labeled seafood products. Li et al. (2016) also used CVM to study consumers' WTP for beef grown using climate friendly production practices.

The WTP guiding technology, which includes bidding game, open-ended questions, the single or double-ended dichotomous choice questions and the payment card, etc. (Cameron and Quiggin, 1998), is the soul of the CVM. In the open-ended survey, respondents were asked to give their maximum WTP value directly, which would lead to a lack of robustness of the subsequent estimation. As for dichotomous choice, although this method is simple and intuitive in survey, it is not easy to make data statistics. Based on Yang et al. (2018), payment card avoids the starting point deviation of dichotomy selection, prevent the high non-response rate on open-ended. Therefore, in this study, the payment

Table 3
Descriptive statistics of subjective self-evaluation and environmental literacy.

	Items	Description			Mean	Cronbach's α	Weighted mean
Subjective self-evaluation	I'm concerned about food safety	Disagree 6.47	Have no idea 32.99	Agree 60.54	2.54	0.67	2.38
	I'm concerned about food nutrition	Disagree 9.15	Have no idea 60.02	Agree 30.83	2.21		
Environmental literacy	The frequency of using biodegradable plastic bags	Never 73.48	Sometimes 16.44	Always or often 10.08	1.37	0.83	1.61
	The frequency of sorting domestic solid waste	Never 53.34	Sometimes 34.12	Always or often 12.54	1.59		
	The frequency of saving water or electricity	Never 34.53	Sometimes 43.27	Always or often 22.2	1.88		
	The frequency of donating time or money to environmental protection organizations	Never 57.35	Sometimes 26.82	Always or often 15.83	1.58		

card was adopted to collect survey data. A sheet with a number of monetary amounts was presented, the respondents must tick the sums that best describe their maximum WTP.

The mathematical average WTP for GMR of consumers calculated by using CVM based on the payment card can be estimated by the following formula:

$$E(WTP) = \sum_{i=1}^{n} A_i P_i \quad (2)$$

where $E(WTP)$ is the consumers' WTP for GMR; A_i and P_i denote the degree and probability of WTP respectively.

4.3.2. Economic model

(1) Parametric estimation:ordinary least square regression

In previous studies, the ordinary least square (OLS) regression model was widely used to reveal the factors influencing consumers' WTP (Riccioli et al., 2020). According to Xu et al. (2020), the OLS function can be expressed as:

$$WTP = \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + \varepsilon \quad (3)$$

where x denotes the explanatory variable, β and n are the coefficient and the number of the explanatory variables, respectively, and ε is the error term. The explanatory variables selected in this study include: the socioeconomic characteristics such as age, gender, the highest education completed, marital status, annual household income, household size, children in household; consumption habits including the primary food

shopper in household and the most common place to buy foods; awareness of pro-environmental attribute (GMR_en)/safety attribute (GMR_sa)/nutritional attribute (GMR_nu); consumers' environmental literacy (Env_li) and subjective self-evaluation (Sub_se).

(2) Parametric estimation:weibull regression model

Weibull regression was originally used to explore the relationship between product life and its influential factors in survival analysis (Sahu et al., 1997; Hosmer et al., 2000). In the last two decades, the application of this model in environmental value assessment has been increasing, especially in the individual's WTP for environmental protection (Hutchinson et al., 2001; Scandizzo and Ventura, 2010). Advantages of Weibull regression in WTP analysis include (Zhang, 2016): (1) full maximum likelihood can be used to estimate parameters; (2) residuals can represent the difference between observed and estimated values of WTP. Therefore, the following basic structure of the Weibull regression was established to reveal consumers' WTP for GMR:

$$ln(WTP) = \beta_0 + \beta_1 x + \sigma \varepsilon \quad (4)$$

where β_1 is the coefficient for corresponding covariate, ε follows extreme minimum value distribution $G(0, \sigma)$, and σ is the shape parameter.

The hazard function of Weibull regression in proportional hazards form can be expressed by the following function:

$$h(WTP, x, \beta, \lambda) = WTP^{\lambda-1} e^{-1(\beta_0 + \beta_1 x)} = WTP^{\lambda-1} e^{-\lambda\beta_0} e^{-\lambda\beta_1 x} = \lambda WTP^{\lambda-1} e^{-\lambda\beta_1 x}$$
$$= h_0(WTP) e^{\theta_1 x}$$

$$(5)$$

where $\gamma = e^{\frac{-\beta_0}{\sigma}} = e^{\theta_0}$, $\theta_0 = -\beta_1/\sigma$, and the baseline hazard function is $h_0(WTP) = \lambda\gamma t^{\lambda-1}$. $\gamma = 1/\sigma$ is usually called a scale parameter. Parameter θ_1 has a hazard ratio (HR) interpretation for subject-matter audience.

(3) Semi-parametric estimation: Cox PH

Cox PH is a semi-parametric estimation method that was originally used to analyze the effects of different types of covariables on survival time. Subsequently, the application scope of the model has been greatly expanded, such as widely used in assessing individuals' WTA or WTP. It is defined as a semi-parametric model because it does not make any requirements on the distribution type of the baseline Hazard function and therefore does not rely on the assumption of a specific distribution when making parametric estimates. The formula of the Cox PH model in our paper is:

$$h(t) = e^{\beta x}h_0(t) \tag{6}$$

The survival function matching Equation (6) is:

$$S(WTP; x) = S_0(WTP)^{exp(\beta x)} \tag{7}$$

where $S_0(WTP)$ represents the baseline survival function at the WTP level. We further combined Equation (6) and Equation (7) to obtain Equation (8):

$$ln[h(WTP, x)]/h_0(WTP) = \beta x \tag{8}$$

Partial maximum likelihood is usually used to estimate the parameter β of Cox PH model. The partial likelihood function can be expressed as:

$$L(\beta) = \prod_{i=1}^{n}\left[exp(\beta, x_i) \bigg/ \sum_{j \in R_i}(\beta, x_j)\right]^{\delta_i} \tag{9}$$

where R_i represents the hazard set at the WTP_i level, $\{j : WTP_j \geq WTP_i\}$.

Natural Logarithm is performed on both sides of Equation (9) to obtain Equation (10):

$$lnL(\beta) = \sum_{i=1}^{n}\left[\delta_i\left(\beta'x_i - ln\sum_{j\in R_i}exp(\beta'x_j)\right)\right] \tag{10}$$

In accordance with the principle of $\partial lnL(\beta)/\partial\beta = 0$, parameter β can be estimated as follows:

$$\widehat{S}_0(WTP) = exp\left[-\sum_{i:WTP_i \leq WTP}\delta_i\left(\sum_{j\in R_i}e^{\widehat{\beta}xj}\right)^{-1}\right] \tag{11}$$

In this paper, Stata 16 was used to perform the necessary descriptive statistical analysis and empirical analysis. Before the empirical analysis, a series of data cleaning works, such as missing value filling, outlier detection and deduplication processing, were carried out. Hot deck imputation was used to fill in missing values, descriptive statistical analysis was applied to detect outliers, and ordering method was adopted to conduct de-repetition.

5. Results

5.1. Descriptive statistics of consumers' responses

5.1.1. Subjective self-evaluation and environmental literacy

The survey gathered self-evaluated data that address food safety and nutrition. 589 respondents, or 60.54% of the sample, indicated a concern in food safety inspired by the deterioration of the agricultural environment. This fact is quite different from the assertion by Hermann (2009) that residents in developing countries do not pay much attention to food safety. Note that as China is the world's second largest economy,

the consumption habits of consumers, especially urban consumers, are closer to those of developed countries, and food safety has become a common concern of the public. However, the food nutrition does not seem to attract widespread public attention. Nearly 70% of respondents indicated they disagree with or have no idea towards the statement "I'm concerned about food nutrition". Cronbach's α is 0.67, indicating that the two items related to food safety and nutrition can be used to reflect subjective self-assessment.

For city dwellers, they have more or less adopted pro-environmental practices in their daily life, either because of the intrinsic environmental awareness or for the sake of saving living costs. Our survey gathered more detailed information on respondents' PEBs adoption preferences. A majority of respondents indicated an interest in cost-saving PEBs. 43.27% and 22.20% of respondents claimed they are sometimes or often involved in water and electricity saving initiatives. However, with respect to the non-cost-saving PEBs, the frequency of respondents' participation was generally low. The mean score of using biodegradable plastic bags, sorting domestic solid waste and donating time or money to environmental protection organizations was only 1.37, 1.59 and 1.58, respectively. Cronbach's α is 0.83, indicating that the four items related to daily PEBs can be used to reflect the general situation of residents' environmental literacy.

5.1.2. Consumers' awareness

Consumers' awareness of the three attributes of GMR was investigated. Before the information intervention, the respondents generally had a low awareness of the safety and nutritional attributes of GMR. After the information intervention, respondents expressed a higher level of awareness of GMR attributes, with 60.94%, 48.21% and 63.11% of respondents showing excellent awareness of the safety, nutritional and pro-environmental attributes, respectively. Comparison results show that information intervention significantly improved the respondents' awareness of GMR attributes.

5.1.3. Consumers' stated WTP for GMR

Consumers' stated WTP is reported in Fig. 4. Prior to information intervention, approximately 80% of the surveyed consumers reported a relatively low WTP (<80% price premium), of which 28.66% protested any payment. By contrast, only 12.20%, 4.64% and 2.21% of respondents were willing to pay a premium of 81–120%, 121–160% and 161% and above, respectively. From the perspective of city differentiation, most consumers in Changsha were unwilling to pay a premium for GMR, while a majority of consumers in the other three cities choose to pay a premium of 41–80%. After the information intervention, 85.35%
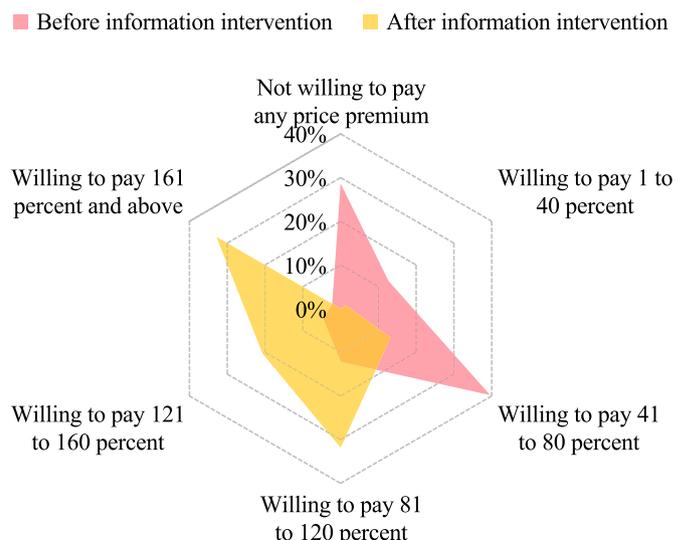
Fig. 4. Changes in consumer WTP under information intervention.

of respondents were stated a relatively high WTP (>80% premium), of which more than 50% were willing to pay more than 120% premium. Interestingly, due to the positive induction of information, the percentage of consumers protesting premium in all sample cities decreased from 28.66% to 0, indicating that the information intervention significantly improved consumers' payment structure and WTP.

5.2. Estimation of consumer WTP for GMR

### 5.2.1. Estimation results

The estimation results of consumer WTP for sub-sample and pooled sample are demonstrated in Table 5. Before the information intervention, consumers' price premium for GMR was 49.33%, which was 2.6 CNY/kg higher than the price of conventional rice, equivalent to a WTP of 7.9 CNY/kg. From the perspective of city heterogeneity, consumers in Hefei have the highest price premium, which was 53.63%, equivalent to a WTP of 8.9 CNY/kg, followed by Nanchang and Changsha, whose WTP was 7.9 CNY/kg and 7.6 CNY/kg, respectively. Consumers in Wuhan have the lowest WTP, which was 7.4 CNY/kg. According to National Bureau of Statistics of China (2020), per capita disposable income in Changsha was 51.8 thousand CNY, higher than the other three cities, while Nanchang has the lowest level. Such inconsistency between payment ability and WTP makes it meaningful to explore the influencing factors from a broader scope other than family economic status.

After respondents view information, the price premium of consumers was significantly improved. Consumers in Changsha saw the largest increase amplitude in price premium, reaching 218.72%, followed by Hefei, and consumers in Wuhan and Nanchang had similar increase amplitude, reaching 142.95% and 142.57% respectively. Across the pooled sample, the average price premium for GMR was 128.62%, which was 6.8 CNY/kg higher than the price of conventional rice, equivalent to a WTP of 12.1 CNY/kg. It can be seen that the consumer WTP after the information intervention was 4.2 CNY/kg higher than that before the information intervention, and this premium can be regarded as the value of information. Furthermore, without controlling for any other factors, informational intervention contributes to a more consistent consumer WTP across cities (S.D. decreased from 4.45 to 0.89).

5.2.2. Environmental and economic performance of GMR premium

A simplified market in which GMR in the husk (GMRH) is processed

Table 4
Descriptive statistics of consumers' awareness.
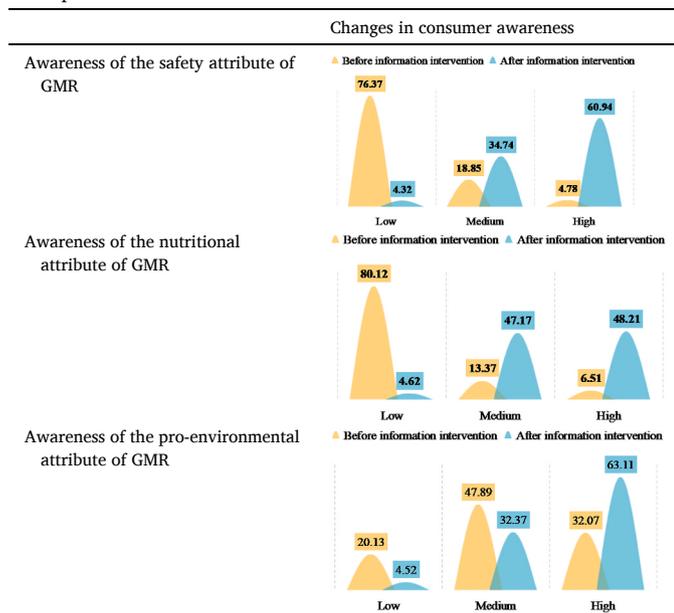
and packaged by processors (rice enterprises or cooperatives) into a finished product (GMR), who then sell it directly to consumers[1] (see Fig. 5), was examined. The processing and packaging actions bring about the increase of the intrinsic value of the product, which determines the legitimacy and inevitability of the processor to grab part of the benefits from the value chain. It is clear that farmers cannot get the total price premium paid by consumers.

What percentage of the price premium can be allocated to farmers? To address this question, two parameters, the processing premium ratio (81.4%) and the packaging premium ratio (43.2%) of rice,[2] were extracted from the previous literature (CGMRS, 2021). Considering that the processing and packaging of GMR is not significantly different from that of conventional rice, so the two parameters could be used as the alternative parameters of GMR. Accordingly, the estimated selling price of GMRH is shown in Table 6.

If the price of GMR is measured by WTP, the corresponding selling price of GMRH before and after information intervention is 3.1 CNY/kg and 4.6 CNY/kg, which is equivalent to 39.2% and 38.0% of the respective total premium. In 2019, the average price of conventional rice in the husk sold by farmers in SRR is approximately 2.1 CNY/kg (National Bureau of Statistics of China, 2020), and the yield of GRMH is about 7605 kg/ha (CGMRS, 2019), the spillover benefits of farmers before and after information intervention is 7605 CNY/ha and 19012.5 CNY/ha, respectively.

A previous study has shown that although the incremental production cost of adopting RGRS is 2169 CNY/ha, farmers are willing to adopt this agro-environmental practice only when they get an amount of no less than 3322.5 CNY/ha (Li et al., 2020). The results of this study show that under the current consumer WTP, farmers can obtain spillover benefits not only higher than the production costs, but also higher than their willingness to accept, both before and after the information intervention. Obviously, as long as the GMR market is well established, market-based solutions in the popularization of RGRS have the potential to be a good substitute for government eco-compensation.

5.3. Factors affecting consumer WTP for GMR

In this section, three regression models - OLS, Weibull and Cox PH - were conducted to understand factors influencing Chinese consumers' WTP for GMR. Multicollinearity among control variables was tested and found that the variance inflation factor (VIF) was within the acceptable range. The mean VIF was 2.04 with a range of 1.03–3.92 (see Table 7).

Table 8 presents results from the pooled data. In the two parameter estimation models, OLS and Weibull, there are respectively seven and six factors that have an impact on consumer WTP. Among them, the four factors of *Primary food shopper in household*, *Sub_se*, *Env_li* and *GMR_en1* play a significant role in the two models. Semi-parametric estimation shows that eight factors including *Female*, *Marital status*, *Annual household income*, *Children in household*, *Primary food shopper in household*, *Supermarket*, *Sub_se*, *Env_li*, and *GMR_en1*, would affect WTP. The goodness of fit of the three models was compared by calculating AIC and BIC, and results showed that the AIC and BIC values of the Cox pH model were significantly lower than those of the other two models (see Appendix Table), indicating that the non-parametric estimation was more suitable for this study. Accordingly, the results of the Cox PH model will be adopted for analysis.

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[1] According to our survey, about 92% of rice processors in southern China choose to sell the finished rice directly rather than link up with specialist retailers.

[2] The processing premium ratio refers to the ratio of the price increment brought by the link of processing rice in the husk into rice that can be directly eaten to the price of rice in the husk, while the packaging premium ratio refers to the ratio of the price increment brought by the packaging of bulk rice into the market to the price of bulk rice.

Table 5
Estimation of consumer WTP for sub-sample and pooled sample.

Consumers' WTP	Before information intervention						After information intervention					
	Changsha	Wuhan	Nanchang	Hefei	Mean	S.D.	Changsha	Wuhan	Nanchang	Hefei	Mean	S.D.
Price Premium (%)	40.44	50.93	52.34	53.63	49.33	4.45	128.89	128.27	127.16	130.09	128.62	0.89
Price of CR (CNY/kg)	5.4	4.9	5.2	5.8	5.3	—	5.4	4.9	5.2	5.8	5.3	—
WTP value (CNY/kg)	7.6	7.4	7.9	8.9	7.9	—	12.4	11.2	11.8	13.4	12.1	—

Note: CR:conventional rice. The price of CR was based on the average retail price of the long-shaped rice in the surveyed cities during the six previous months. Data from "China agricultural product price information network".
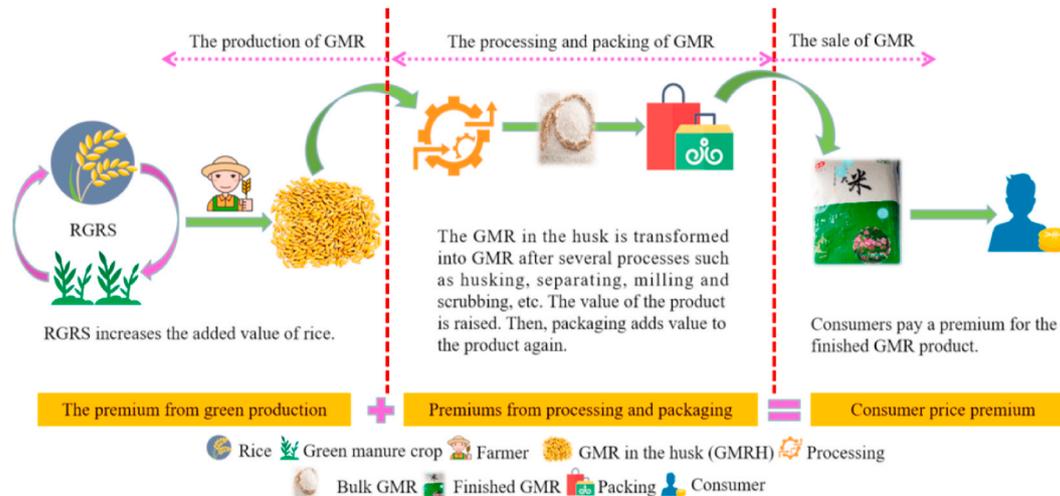

Fig. 5. The source of GMR premium. Note: *the GMR mentioned above refers to the finished GMR product.*

Table 6
The allocation of price premium.

	Farmer's selling price of GMRH	Price of GMR in bulk	Processing premium ratio (%)	Market price measured in WTP	Packaging premium ratio (%)
Before information intervention: (CNY/kg)	3.1	5.5	81.4	7.9	43.2
After information intervention: (CNY/kg)	4.6	8.4	81.4	12.1	43.2

Table 7
The multicollinearity diagnosis of independent variables.

variable	VIF	variable	VIF
Female	1.15	Little retailers	2.45
Age	1.89	Supermarket	3.87
Education 1	2.83	Sub_se	1.18
Education 2	3.92	ENV_li	1.03
Education 3	3.40	GMR_sa1	1.79
Marital status	2.02	GMR_nu1	1.90
Annual household income	1.18	GMR_en1	1.97
Household size	1.31	Changsha	1.73
Children in household	1.42	Hefei	1.55
Primary food shopper in household	1.12	Nanchang	1.59
Local market	3.47		

Cox pH estimates showed that the female and marital status variables were positive and significant, implying that married women were more likely to pay GMR. The positive and significant coefficient of income implies that economic status is a crucial factor that determines whether consumers pay for GMR or not. Households with young children were willing to pay more for GMR than those without young children. We also found that those with rich shopping experiences are more likely to pay more for GMR. In addition, regional factors were introduced into the model as dummy variables, however, no significant effect from these four cities were observed.

A statistically significant positive relationship exists between consumers' subjective self-evaluation and their WTP for GMR. That is, consumers who are concerned about food safety and nutrition were more willing to pay a higher premium for GMR. Another interesting finding was consumers' environmental literacy increases their WTP for GMR. Most importantly, we examined consumers' awareness of GMR's attributes of safety, nutritional and pro-environmental, and found that the other two variables were not statistically significant except for the pro-environmental attribute. This could be because, as an emerging food, the whole consumer group, rather than some consumers with specific characteristics, lacks a clear understanding of it's inherent safety and nutritional attributes. This is in line with the descriptive findings in Table 4. There is a significant positive correlation between consumers' awareness of pro-environmental attribute and WTP, which means that consumers with higher awareness of this attribute are more willing to pay a higher price for this product.

Further analysis for the WTP grouped samples as conducted by performing the homogeneity test of variance and the results are shown in Fig. 6. Obviously, consumers' awareness of pro-environmental attribute in the high WTP group was significantly higher than that in the medium and low WTP groups, while there was no significant difference in consumer awareness in the medium and low WTP groups. This indicates that for every high consumer WTP, there will always be a high

Table 8
Determinants of consumer WTP. Dependent variable: WTP before information intervention.

Variable	OLS		Weibull		Cox PH	
	Coef.	S.D.	Coef.	S.D.	Coef.	S.D.
Female	−0.120	0.079	0.278***	0.088	0.146**	0.063
Age	0.004	0.005	−0.008	0.006	−0.003	0.004
Highest education completed (dummy, base = Education 4)						
Education 1	−0.288	0.179	−0.287	0.208	−0.103	0.147
Education 2	−0.066	0.144	−0.173	0.147	−0.081	0.085
Education 3	−0.035	0.149	−0.240	0.159	−0.121	0.092
Marital status	0.250*	0.106	0.075	0.125	0.089**	0.082
Annual household income	0.022**	0.003	0.014	0.003	0.009**	0.002
Household size	−0.039	0.026	−0.102	0.037	−0.057	0.024
Children in household	0.301	0.087	0.099**	0.099	0.041*	0.065
Primary food shopper in household	0.136***	0.034	0.093*	0.052	0.080**	0.040
Primary place to buy foods (dummy, base = Online)						
Local market	0.107	0.126	0.278	0.205	0.227	0.125
Little retailers	0.086	0.120	0.207	0.223	0.169	0.146
Supermarket	0.560***	0.168	0.038	0.192	0.072	0.116
Sub_se	0.190**	0.088	0.209*	0.107	0.119*	0.072
Env_li	0.031*	0.085	0.128**	0.089	0.055***	0.061
GMR_sa1	0.362	0.087	0.100	0.112	0.144	0.072
GMR_nu1	0.153	0.083	0.161	0.102	0.092	0.064
GMR_en1	0.250***	0.088	0.040**	0.098	0.068**	0.060
City (dummy, base = Wuhan)						
Changsha	−0.097	0.106	−0.008	0.119	0.031	0.078
Hefei	−0.036	0.108	−0.044	0.111	0.022	0.071
Nanchang	0.027	0.105	0.067	0.108	0.044	0.069
Constant	0.058	0.360	−1.768***	0.492		
R squared	0.2235					
/ln_p			0.978***	0.028		
p			2.659	0.073		
1/p			0.376	0.010		

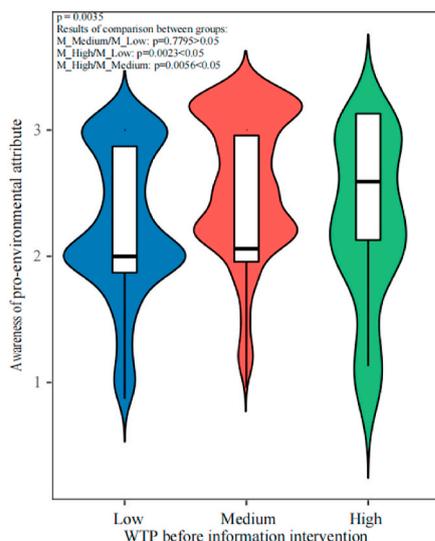Note:"***", "**", "*" significant at the 1%, 5%, 10% level, respectively.

Fig. 6. The impact of awareness of pro-environmental attribute on different WTP groups. Note: WTP<3, =3, >3 were identified as Low, Medium and High, respectively.

level of pro-environmental awareness that matches it, while low awareness is not a necessary condition for low WTP.

5.4. Reactions of consumers' WTP to information

5.4.1. Estimation results and robustness check

Further insights to the drivers of WTP changes are presented in Table 9. As can be seen, consumers' awareness of the safety and nutritional attributes of GMR began to have a significant positive impact after information intervention, meanwhile, the awareness of pro-environmental attribute still remains significant in positively influencing WTP. This brings the enlightenment that information intervention can be used as a policy tool to improve urban consumers' cognition of GMR, regulate consumers' WTP, and then affect the development of GMR industry. In fact, previous research has also made the same claim. For instance, Wechel and Wachenheim (2002), Bowera et al. (2003) and Umberger et al. (2010) all highlighted the important role of information intervention when studying consumers' WTP for specific foods.

For robustness check, the Schoenfeld residuals were estimated. Schoenwald residuals is a most effective statistical tool for testing the proportional hazards hypothesis. If the residual does not change regularly with the change of WTP, the proportional risk hypothesis can be valid. The fitting results of residual and WTP are shown in Fig. 7. The three red lines in the figure have a roughly zero slope, suggesting that the estimation results are robust enough.

5.4.2. Heterogeneity of information impacts

Fig. 8 shows the results of the heterogeneity of information impact. Kaplan-Meier Estimates indicate that when the initial WTP was low, the increment of WTP after the information intervention was larger. In other words, consumers with lower initial WTP for GMR seemed to approach to the information related to this food favorably, increasing WTP significantly, while those with high initial valuations were slower in response to the information. This can be explained by the fact that most respondents with higher initial WTP also had higher GMR awareness, and therefore probably already had some food information related to GMR. This is consistent with the results shown in Fig. 6. In this case, providing them with information would have a less psychological impact, and their WTP would not increase much.

5.5. Testing results of the hypotheses

Table 10 shows the testing results of the hypotheses of this study. Before the information intervention, subjective self-evaluation and environmental literacy have a significant positive impact on consumers' WTP, which verified H1 and H2. The awareness of pro-environmental attribute has a significant positive impact on WTP, however, the awareness of safety and nutritional attributes were not statistically significant. Therefore, H3 was partially supported. After the information intervention, consumers' WTP for GMR increased by 160.73%, verifying H4. Meanwhile, the awareness of safety attribute and awareness of nutritional attribute began to have significant effects on WTP, which verified the existence of the moderating effect in H5. In addition, results

Table 9
Reactions to information, Cox PH estimation dependent variable: WTP after information intervention - WTP before information intervention.

Variable	Cox PH	
	Coef.	S.D.
GMR_sa2	0.016***	0.055
GMR_nu2	0.057***	0.062
GMR_en2	0.006***	0.049
Other variables: have been controlled.		
Log pseudolikelihood	−5009.986	

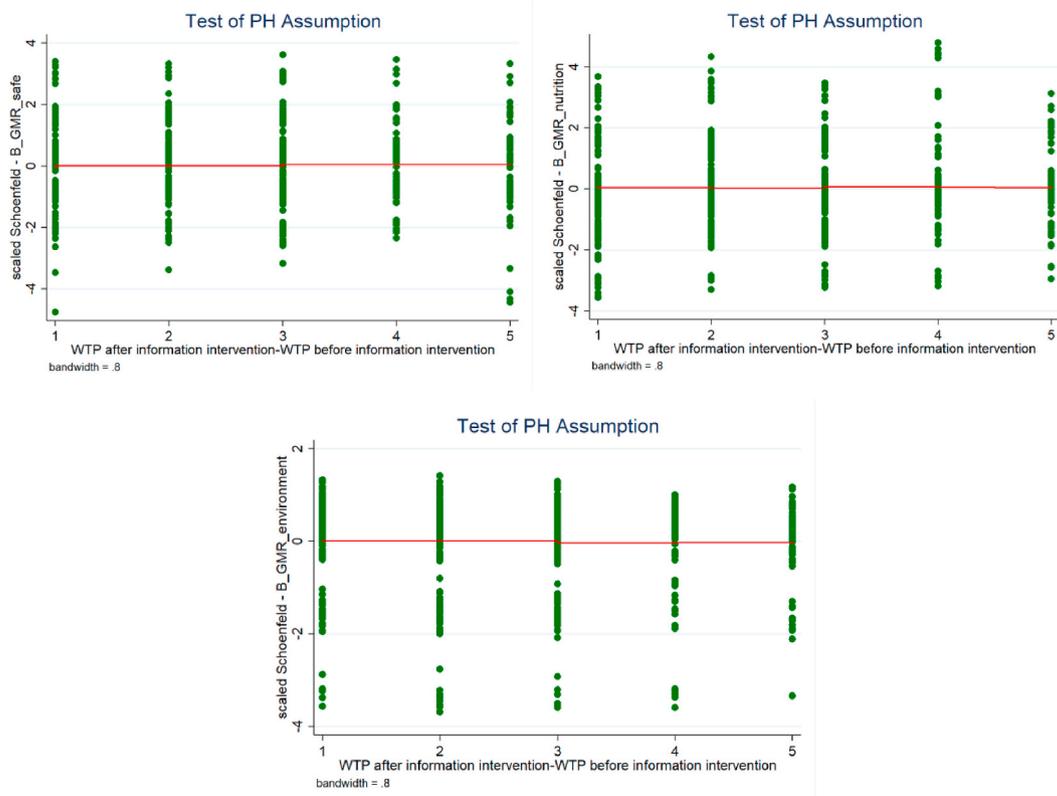Note:"***", "**", "*" significant at the 1%, 5%, 10% level, respectively.

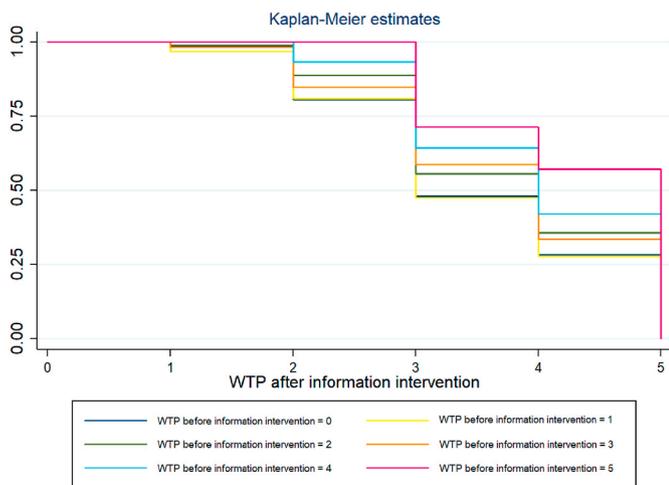**Fig. 7.** Robustness check of Cox PH based on Schoenfeld residuals.

Fig. 8. Influence of information intervention on initial WTP change.

of heterogeneity of information impacts show that information intervention had a greater impact on consumers' payment with low initial WTP, which verified H6.

6. Discussions and implications

6.1. Discussions of research findings

This study revealed whether Chinese consumers are willing to pay a premium for GMR and what factors will affect their payment. The interesting topic of payment level was firstly analyzed. It was found that the average WTP of the pooled respondents was 7.9 CNY/kg, approximately 2.6 CNY/kg higher than the price of conventional rice. This result verifies the hypothesis that Chinese consumers intend to pay a premium for PEF produced by the pro-environmental practice. Results of information intervention experiment show that consumers' WTP can be greatly improved by food information, which means that the emerging food market can be catalyzed to maturity more quickly by making full use of the information tools. This is in line with findings of Lange et al. (2003) and Wongprawmas and Canavari (2017). Another important finding was that consumers' WTP for GMR is sufficient to cover farmers' production costs, even higher than the amount of compensation that

Table 10
Testing results of the hypotheses.

Hypothesis	Description	Testing results
H1	Subjective self-evaluation ⟶+ WTP	Supported
H2	Environmental literacy ⟶+ WTP	Supported
H3	Safety, nutritional and pro-environmental attributes ⟶+ WTP	Partially supported
H4	Information intervention ⟶+ WTP	Supported
H5	Information intervention ⟶+ WTP and consumers' awareness	Supported
H6	information intervention ⟶+ Range of change in WTP	Supported

farmers expect to obtain. This finding is also of great significance to policy makers of agricultural environmental management.

Another question worth paying attention to is what factors will influence consumers' WTP for GMR? The fact that consumers' willingness is often influenced by their socio-economic characteristics cannot be ignored (Gifford and Bernard, 2011; Bai et al., 2013; Sichtmann and Stingel, 2013). Our research found that the married people and women are more likely to pay a higher premium for GMR, which enlightens that market nurturer of GMR should pay special attention to the consumption behavior of this segment of consumers. The significant positive correlation between consumers' household income and their WTP indicates that consumers with perfect family economic status also exhibited greater efforts in payment. This is expected as households with higher incomes are expected to have higher purchasing power than those with less, and this would increase the probability of purchasing expensive food products (Chege et al., 2019).

This study also found that households with young children were willing to pay more for GMR than those without young children. Bearing in mind that Chinese parents generally pay special attention to the growth of their children, it is understandable that they would be willing to invest a large amount of money to buy quality food. In fact, our survey showed that households with young children have a WTP nearly 40% higher than those without young children. In order to cope with the adverse effects of aging, the Chinese government has recently released a series of policies to encourage the birth of children (The Central People's Government of the People's Republic of China, 2021). Policy makers could capture the opportunity to introduce GMR to consumers, improve their awareness and consumption preferences, and thus accelerate the development of this PEF. The positive correlation between primary food shopper in household and WTP shows that consumers with rich shopping experiences are more likely to pay more for GMR. This is in line with findings elsewhere, such as Hoffmann and Broekhuizen (2010) and Chege et al. (2019). This may be because people with rich shopping experiences are more likely to discriminate food quality information and pay premiums for high-quality foods.

As expected, consumers with positive subjective self-evaluation also exhibited more openness in paying for GMR, which is in line with results from Rocha et al. (2013), who found that the more concerned about food safety and nutrition, the more likely consumers were to pay premiums for high-quality foods. According to the fact mentioned above, some enlightenment can be summed up. First, guiding people to better understand the potential risks in food market is an effective way to stimulate them to pay a premium for GMR. Second, leading more consumers aware of their own demand for safe and nutritious food is the guarantee for the sustainable development of GMR market. It is thus crucial to understand how to expand the focus group of the GMR industry and how to increase the level of consumer concern(Samoggia and Riedel, 2019; Wilson and Lusk, 2020).

Interestingly, environmental literacy, has emerged as another important predictor of consumers' premium for GMR. These results align with those of Zhou et al. (2017) and Li et al. (2021a,b), who found that consumers with higher environmental literacy were more likely to pay a higher premium for a specific PEF. This may be because the spillover effects of daily PEBs make consumers with higher environmental literacy more likely to be catalyzed into other PEBs with similar underlying processes (Li et al., 2021a,b). In fact, the various PEBs held by individuals are not independent of each other. There is an internal connection between them, which has been found by many scholars such as Werff et al. (2014) and Nilsson et al. (2017). Our survey also supports the existence of spillover effect of environmental behavior in GMR consumption to a certain extent. Approximately 60% of respondents with the intention to pay a premium for GMR had engaged in at least one of the PEBs, and further, consumers that perform more environmental acts have a stronger intention to pay.

Somewhat unexpectedly, results showed that before the information intervention, only pro-environmental attribute among the three GMR attributes had a significant positive effect on consumers' premium for GMR. This significant impact may have something to do with the information that the name of this food leaks out. In our survey, when the name of the food was displayed to the respondents, some of them were already aware of the impact of the food production on the environment. This fact seems to support the above assertion. Surprisingly, the influence of the three attribute variables on the GMR premium became statistically significant after the information intervention. Previous research has also found evidence that the provision of information changes the individual awareness towards food safety and nutrition (Koc, 2009). Our study, as well as work by Koc, can be both explained by the Bayesian decision theory, which elaborates that when the individual is exposed to new information, an updated belief will be molded by combining prior beliefs and new information.

More importantly, the heterogeneous impacts of information provision on differentiated initial WTP indicate that information intervention can help to narrow the gap of payment amount between different consumer groups. In a similar vein, Wilson and Lusk (2020) found that consumers with higher initial premiums appear to have a smaller increase in WTP premiums than those with lower initial premiums in response to the information. As for an emerging food, regulating consumers' WTP to improve market stability is a necessary process to catalyzed the rapid maturity of the industrial chain, and our finding as well as work by Wilson et al., has identified an effective tool for stabilizing the GMR market, which has important implications for policymakers.

6.2. Implications

Chinese consumers' WTP for GMR is not only related to the upgrading of the GMR industry, but also determines farmers' decisions of adopting RGRS. However, due to the novelty of this food, previous studies have rarely explored consumers' purchasing preferences and payment behaviors for it. The findings of this study provide enlightenment for consumption and environmental policy making related to GMR and RGRS.

Specifically, in view of consumers' positive willingness to pay for GMR, the GMR market has the potential for upgrading. Since the supply of information can greatly promote consumers to pay a premium, it is necessary to develop efficient and easy-to-use information intervention tools for the development of the GMR market. The study found that farmers' income from GMR production is higher than the amount of eco-compensation that they expect to obtain from RGRS, therefore, RGRS can be promoted sustainably while reducing the financial burden of the government, as long as the GMR market is set up and running smoothly. Further, the study indicates that increasing consumers' subjective and objective knowledge of food industry is conducive to a more positive self-assessment by a wider group, thereby, a professional knowledge dissemination system for the food industry should be established to improve consumers' concerns about food safety and nutrition (Samoggia and Riedel, 2019; Wilson and Lusk, 2020). The results also demonstrate the positive impact of environmental literacy, this finding provides policy makers with the enlightenment that it is feasible to motivate consumers to pay for GMR by strengthening their environmental awareness and enhancing their daily PEBs. In addition, the information intervention significantly improved consumers' understanding of the attributes of GMR, which in turn indirectly improved consumers' WTP. This once again highlights the important value of information intervention tools in the industrial upgrading and market cultivation of GMR, and suggests that policy makers should actively explore and develop diversified information intervention tools.

It should be pointed out that this study has deeper implications for academics and policymakers. On the one hand, it is one of the few literature currently exploring consumers' willingness to pay for GMR, an emerging pro-environmental food with great market potential. On the other hand, the higher precision semi-parameter estimation method and

the test process in this study can be generalized to a great degree and can be used to other research on consumer payment behavior. Moreover, the study results and policy implications may also be suitable for other emerging pro-environmental foods in China and even in other developing economies.

7. Conclusions

Green manure-rice (GMR), the end product of RGRS, emerging as a novel PEF in the rice market of southern China. Determining consumers' payment decisions for GMR is a key part of accelerating the cultivation of this market. Unfortunately, previous research has paid little attention to this topic. This study therefore aims to reveal Chinese consumers' willingness to pay for GMR and its determinants by conducting an information intervention experiment.

To be specific, the WTP for GMR among urban consumers in southern China was firstly estimated by employing CVM. Results showed that consumer WTP before and after the information intervention was 7.9 CNY/kg and 12.1CNY/kg, which was 2.6 CNY/kg and 6.8 CNY/kg premium than that of conventional rice, respectively. This result is important for at least two reasons. On the one hand, the result implies that, as long as the GMR market is established, market-based solutions can be a good substitution for governmental eco-compensation in the popularization of RGRS, even without external information intervention. On the other hand, the result highlights the important role of eliminating information asymmetry in the pro-environmental food market through external information supply. Afterwards, the decision mechanism by which consumers pay for GMR was explored by using a series of parametric and semi-parametric estimation models. The main conclusions are as follows. First, both subjective self-evaluation and environmental literacy had a positive and significant impact on consumer premium. This finding provides policymakers with the enlightenment that it is feasible to raise consumer premium by actively guiding their subjective self-evaluation and fostering their environmental literacy. Second, the moderating effect of information intervention on consumer awareness of GMR attributes was identified. This result not only emphasizes the positive role of food attribute labeling in guiding consumers' payment, but also further verifies the effectiveness of information strategy in promoting the development of GMR market. Third, information intervention narrowed the gap of payments between different consumer groups, which provides instrumental support for stabilizing the GMR market.

Compared with previous studies, the scientific value of this study is reflected in the following aspects. First of all, it is an unprecedented work to estimate consumers' willingness to pay for GMR, and the results have important guiding significance for regulating the price of GMR and standardizing the product market. Second, the factors that affect consumers' payment for GMR are prospectively and systematically revealed thereby informing strategies to promote GMR market from a China rural revitalization context. Third, this study contributes to the literature on the effectiveness of market-based economic induction as alternatives to government-led eco-compensation policies in maintaining farmers' pro-environmental behaviors.

The limitations of the study are inevitable. On the one hand, a limited number of sample cities were chosen, which limits the generalization of the study results. In this paper, only four provincial capitals were selected as representatives, while other cities of the same size in the SPR, as well as some medium and small cities were not taken into consideration. On the other hand, the data in this study came from online survey, which may be followed by problems associated with sample selectivity bias. Some of the subjective questions in the questionnaire are based on consumers' self-reported answers, and due to the lack of supervision mechanism in online survey, it is not guaranteed that consumers will answer these questions as truthfully as possible.

Further study is required, as there existed the above limitations. Future studies should expand the data collection scope to more cities of different sizes to improve the representativeness of the sample. Moreover, face-to-face survey should be applied to verify the reliability of online data. Considering that consumers' payment behavior has more guiding value for policy making, the research dimension should be expanded from willingness to behavior in the future to explore consumers' behavior mechanism in the real market.

CRediT authorship contribution statement

Fuduo Li: Conceptualization, questionnaire development, Project administration, Methodology, Investigation, Data curation, Project administration, Software, Formal analysis, Writing – original draft, Visualization, Writing – review & editing, Validation. **Kangjie Zhang:** Investigation, Writing – original draft, Project administration, Validation, Writing – review & editing. **Peng Yang:** Conceptualization, Supervision, Resources. **Jian Jiao:** Software, Data curation. **Yanshu Yin:** Formal analysis, Writing – review & editing, Visualization. **Yingnan Zhang:** Formal analysis, Writing – review & editing, Visualization. **Changbin Yin:** Project administration, Funding acquisition, Validation.

Declaration of competing interest

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

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Appendix A. Information card presented to respondents

◎绿肥可增加土壤有机质、提升土壤肥力、钝化土壤重金属，进而提升耕地质量和改善农业环境。
◎绿肥大米（GMR）在生产中全程不施用或减量施用化肥（减量率>60%）。
◎GMR上市前需通过安全性和营养性检测。

Green manure increases soil organic matter, enhances soil fertility, and passivates soil heavy metals, thus improving the quality of cultivated land and agricultural environment.

Chemical fertilizers are not used or are used in reduced amounts in the production of GMR (decrement rate > 60%).

The safety and nutrition of GMR must be tested before it can enter the consumer market.

Appendix Table

Comparison of the goodness of fit between OLS, Weibull and Cox PH.

Model	ll(null)	ll(model)	AIC	BIC
OLS	−1594.837	−1444.839	2941.678	3068.568
Weibull	−406.078	−368.165	782.330	886.674
Cox PH	−395.245	−375.797	501.595	613.825

Note: AIC and BIC are short for Akaike information criterion and Bayesian information criterion respectively.

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