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An investigation of consumer willingness to pay for traceable pork accompanied by supplementary quality assurance information

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Introduction: With increasing consumer concern regarding food safety, willingness to pay (WTP) for food has become a significant focal point of research. This study explored consumer willingness to pay for traceable pork in Shanghai with additional quality credit information.

Methods: In October of 2020, 669 valid respondents were surveyed across 15 urban districts in Shanghai. By employing the contingent valuation method and a binary logit model, we empirically analyze consumer WTP for credit-traceable pork and its influencing factors, and estimate the average WTP.

Results: The results indicate the following. (1) As bid prices increase, fewer consumers are willing to pay extra for credit-traceable pork. Specifically, 94.59% of the consumers were willing to pay an additional price when the bid price was 2 yuan/kg, whereas only 10.53% were willing to pay 30 yuan/kg. (2) Nine variables significantly influence consumer WTP for credit-traceable pork: bid price, purchase experience, trust level, concern for pork, confidence in pork, purchasing from specialty stores, local pork purchasing habits, gender, and education level. On average, consumers are willing to pay an additional 8.48 yuan/kg for credit-traceable pork compared with regular pork. Although certain variables do not exhibit a significant impact, the WTP for credit-traceable pork varies considerably among different consumer groups.

Discussion: Based on these findings, we propose strategies to expedite the development of a credit traceability system for agricultural products.

KEYWORDS

credit traceability, contingent valuation method, binary logit model, willingness to pay, agricultural products

1 Introduction

Food quality and safety are critical to public health and safety. Issues related to food safety stemming from information asymmetry, the inability to trace responsibilities, and market failures not only harm the interests of consumers and food enterprises involved in tracing but also impede the overall development of the food industry (Van Rijswijk and Frewer, 2008). In China, the government's approach to addressing food safety issues primarily consists of two strategies. First, a traceability and accountability strategy clarifies responsibilities and intensifies punitive measures. Second, a product differentiation strategy implements quality certification to achieve premium pricing

for high-quality products. As an essential mechanism for addressing agricultural product safety concerns, the effectiveness of traceability systems requires further enhancement.

It is generally acknowledged that there are two approaches to reducing or alleviating information asymmetry related to food quality and safety. The first involves strengthening regulations, clarifying responsibilities, and intensifying punitive measures, which can be implemented through traceability systems, hazard analysis and critical control points (HACCP), and other quality certification frameworks. The second involves the implementation of product differentiation strategies such as the certification of green and organic foods. These approaches are equally applicable to addressing quality and safety issues in agricultural products such as pork and vegetables (Bosona and Gebresenbet, 2018), highlighting the roles of government regulatory and market reputation incentives.

Currently, China's regulatory framework for agricultural product quality and safety primarily emphasizes strengthening oversight, clarifying responsibilities, and intensifying punitive measures, thereby enhancing government regulatory incentives to standardize the quality and safety behaviors of stakeholders within the industrial chain. Product differentiation strategies such as green food certification also play a crucial role in addressing agricultural product quality and safety issues (Zander et al., 2013). However, these strategies are typically adopted only for mid-to-high-end products, leading to coverage limitations and challenges in ensuring the safety of all agricultural products in the market.

Based on international experience, food safety management has gradually evolved from a final-product-centered system that relies heavily on post-market interventions (e.g., food recalls) to a more preventive system that focuses on risk assessment (Cade et al., 2002; Aung and Chang, 2014). With advancements in digital information technology, food traceability systems have become key pillars for ensuring food safety and addressing information asymmetry in the food sector. In recent years, the Chinese government has made significant efforts to enhance regulations, with one important strategy being the construction of agricultural product traceability systems.

Theoretically, the establishment of agricultural product traceability systems helps to reduce or alleviate the extent of information asymmetry, thereby aiding in the resolution of agricultural product quality and safety issues. In practice, the quality and safety assurance role of traceability systems is primarily manifested through the enhancement of the oversight of the quality and safety behaviors of stakeholders across the agricultural product supply chain via accountability mechanisms. As a tool for information disclosure, traceability systems aim to track and trace product safety information throughout the agricultural product supply chain, fostering information sharing and close cooperation between upstream and downstream participants to create an integrated supply chain. This approach addresses the shortcomings of singular control methods and provides product safety information to all stakeholders in the supply chain, including consumers, industrial institutions, and regulators, thereby fulfilling consumer rights to information and choice.

Since the early 2000s, China has explored traceability systems for agricultural products. Notably, the Ministry of Commerce initiated pilot projects for meat and vegetable circulation traceability systems in 2009 and the Ministry of Agriculture promoted the development of agricultural quality traceability systems. With vigorous government support, significant progress has been made in constructing agricultural product traceability systems in China. However, various challenges remain, including difficulties in achieving traceability across the entire industrial chain and the need to enhance the authenticity and reliability of traceability information. Furthermore, relying solely on traceability systems is insufficient to improve agricultural product safety. Tracking products by batch during production is ineffective unless the tracking system is integrated with an effective safety control system. Traceability systems do not inherently create reputational attributes but merely validate their existence.

Consequently, there is an urgent need to explore new approaches for the regulation of agricultural product quality and safety to enhance the effectiveness of traceability systems while further promoting their development. Integrating the credit mechanism concept into agricultural product traceability systems represents a promising approach for improving the regulatory framework for agricultural product quality and safety. With the continuous increase in national quality in China, suitable conditions have emerged to establish a credit-based society, making it feasible to incorporate credit mechanisms into agricultural product quality and safety regulatory frameworks. Such mechanisms can address information asymmetry between enterprises and other stakeholders, creating conditions for repeated strategic interactions that ensure that the benefits of trustworthiness for enterprises exceed the associated costs. Traditionally, the role of agricultural product traceability systems in ensuring quality and safety has primarily been realized through accountability mechanisms that enhance the oversight of the quality and safety behaviors of stakeholders in the agricultural product supply chain. The addition of credit mechanisms to agricultural product traceability systems further strengthens their role in ensuring quality and safety, particularly through product differentiation strategies. The differentiation enabled by traceability system mechanism design is primarily reflected in its impact on corporate reputation. By incorporating corporate credit and enabling end-consumer traceability queries, the traceability system helps maintain and enhance the reputation of an enterprise to a certain extent. For a company with long-term business goals and aspirations to increase its future income, such a traceability system also plays a role in regulating quality and safety behaviors through reputation mechanisms. In summary, the coupled regulation of business entity credit evaluation and agricultural product traceability systems fundamentally makes agricultural product quality and safety information more symmetrical, allowing consumers to be aware of both the product quality and quality credit information of business entities. These conditions facilitate premium pricing for high-quality products and the elimination of inferior products. Additionally, the focus of agricultural product supervision can be shifted directly to business entities by identifying responsible parties.

In practice, the continuous accumulation of agriculture-related credit information and big data makes it possible to regulate the credit of agricultural business entities (Zuo et al., 2010).

Digitalization, big data, and blockchain technologies introduce new opportunities and challenges into the top-level design and construction of traceability systems. Various provinces and cities in China have accumulated experience and practice in integrating agricultural product traceability systems with credit evaluation. For example, Hainan and Guangxi have incorporated the "traceability + credit" mechanism into their 14th Five-Year Plan; Shanghai leads the nation in constructing agricultural product traceability systems, exploring the application of credit evaluation methods such as "Shennong Points" to agricultural product quality safety supervision; and Zhejiang, Sichuan, and other regions are actively exploring and gradually establishing effective agricultural product quality safety credit management methods and development models. In some areas of Henan, a credit and agricultural product traceability system has been established with rice as the core product, forming a complete safety management loop in which the origin can be traced, the destination verified, and responsible parties held accountable. However, there remains a gap between provinces and cities in the coupled regulation of business entity credit evaluations and agricultural product traceability systems. In regions such as Shanghai, attaching traceability codes to agricultural product certificates has achieved a certain degree of effective integration of traceability and credit. However, this approach represents a preliminary form that has not realized dynamic quality credit system evaluation for business entities. Therefore, timely research on coupled regulation mechanisms considering business entity credit evaluations and agricultural product traceability systems can provide significant practical guidance. It should also be recognized that achieving coupled regulatory mechanisms requires relatively high-cost inputs that cannot rely solely on government funding. Understanding whether consumers are willing to pay more for traceable agricultural products with quality credit information, the prices they are willing to pay, and factors influencing this willingness are important for promoting the coupled regulation of business entity credit evaluation and agricultural product traceability systems.

China has conducted extensive research on willingness to pay (WTP) and purchasing behavior for traceable agricultural products (Ying et al., 2012; Yin et al., 2013; Liu et al., 2015; Chen et al., 2021). International studies have mainly focused on the WTP for the traceability characteristics of food origins, particularly traceable beef, pork, and milk (Umberger et al., 2003; Meyerding et al., 2018; Chini et al., 2020; Janssen et al., 2021). Research has shown that both domestic and international consumers value the traceability attributes of agricultural products (Tonsor and Schroeder, 2006; Mørkbak et al., 2010; Ortega et al., 2014; Wu et al., 2015a,b; Lusk et al., 2018; Meixner and Katt, 2020; Shi et al., 2023) and are generally willing to pay a premium for products with traceable information (Zhang et al., 2012; Zheng et al., 2020). Studies have found that during the pandemic, consumers' willingness to pay for vegetables and meat increased significantly, with prices consumers were willing to pay rising by ∼200 and 141%, respectively, compared to pre-pandemic levels (Yue et al., 2021). And consumers are willing to pay a 20% premium for pork from upgraded pork stores in Vietnam during COVID-19 (Ngo et al., 2023).

However, there are significant differences in consumer awareness of agricultural product traceability systems across countries. Consumers in developed countries have a higher level of awareness of traceable agricultural products (Dickinson and Bailey, 2002), with those in Southern European countries (France, Italy, Malta, Slovenia, and Spain) being more knowledgeable than those in Northern European countries (Halawany et al., 2007). In contrast, consumers in developing countries (e.g., Brazil, India, and Mexico) have relatively low awareness of traceable agricultural products (Souza-Monteiro and Caswell, 2004). Although Chinese consumers are highly concerned about agricultural product safety, their awareness of traceable agricultural products is low and their understanding of the traceability system lags behind its development stage (Peng and Chen, 2010; Zhang, 2023).

Agricultural product quality and safety are complex social credit issues, and strengthening spot checks and administrative measures is insufficient to alleviate these issues effectively. Therefore, it is necessary to construct an agricultural product quality and safety credit system to evaluate credit, thereby better utilizing the credit reward and punishment mechanism, strengthening social supervision, increasing the cost of dishonesty, reducing the benefits of dishonesty, and gradually guiding the healthy development of the agricultural product market and the entire industry (Li and Luo, 2020; Xue et al., 2021). Currently, research on credit mechanisms for agricultural product quality and safety is relatively limited and focuses on the definition of the concepts and connotations of agricultural product quality and safety credit (Xue et al., 2021), influencing factors (Wan and Luo, 2011; Liu et al., 2019), indicator system construction (Mao et al., 2018; Mo and Wang, 2019), credit archives and databases (Hobbs, 2006), and regulatory models (Zuo et al., 2010; Li and Luo, 2020; Meng, 2020). The concept of agricultural product quality and safety credit refers to the ability of agricultural product producers and operators to comply with quality and safety standards and not engage in dishonest behaviors that compromise product safety. Quality and safety issues focus on the products themselves, whereas quality and safety credit issues emphasize the characteristics and behaviors of producers and operators (Xue et al., 2021).

The credit evaluation system for agricultural product quality and safety targets producers and operators, providing a multidimensional, dynamic, and comprehensive description of the factors affecting their ability to produce safe and high-quality products, and the likelihood of engaging in dishonest or honest behaviors. Scholars have constructed quality credit evaluation indicators for food production enterprises based on their willingness, capability, and performance (Mo and Wang, 2019). Other studies have developed credit evaluation indicator systems based on aspects such as basic quality, financial status, reputation record, quality control level, input management, as well as the political and economic environments of agricultural product producers and operators (Xue et al., 2017).

With food quality and safety attracting increasing attention, related research has deepened from various perspectives (Haas et al., 2021; Shao et al., 2021; Indiarto et al., 2023). Given the importance of agricultural product safety in the national economy and people's livelihoods, research on agricultural product safety issues has increased; however, studies on the coupled regulation mechanism of business entity credit evaluation and agricultural product traceability systems are scarce. Furthermore, there has

been no research on consumer WTP for traceable pork with additional quality credit information. Considering the significance of pork in the daily diet of Chinese consumers, this study empirically analyzes urban resident WTP for credit-traceable pork and its influencing factors to explore how to improve the coupled regulation mechanism from a consumer perspective. The main contributions of this study can be summarized as follows. First, it provides a new approach and theoretical discussion for solving agricultural product safety issues. The responsibility for agricultural product safety lies with producers and operators, and traditional regulations struggle to trace products back to these entities. Big data offer excellent conditions for credit regulation and traceability systems, enabling a shift from product regulation to entity regulation. This shift will not only improve the post-incident traceability and recall of problematic products but also help in the early detection and prevention of quality and safety risks, covering all business entities, including small farmers. Second, we empirically analyze consumer WTP for credit-traceable pork and the differences in payment willingness across different demographic groups.

2 Construction and mechanism design of an agricultural product credit traceability system

The Ministry of Agriculture and Rural Affairs of China piloted a nationwide edible agricultural product certification system in 2020 to promote the implementation of primary responsibility for agricultural product quality and safety among producers. Edible agricultural product certification is a quality and safety commitment certificate issued by producers for the agricultural products they sell and can be considered as a special form of credit regulation. A complex relationship exists between traceability and consumer WTP. For example, the price consumers are willing to pay is largely related to agricultural product labels (e.g., organic and green certifications) (Wijesinghe and Nazreen, 2020). Furthermore, the level of trust in agricultural product traceability (Liu et al., 2019; Nawi et al., 2023; Tran et al., 2024), concern for food safety (Phuong et al., 2019), and purchasing location (Suhandoko et al., 2021; Zhu et al., 2023) are important factors that influence consumer WTP. High prices and low household incomes have become major obstacles for residents in purchasing traceable agricultural products (Nandi et al., 2017; Zhang et al., 2018; Katt and Meixner, 2020).

Petter Olsen and Melania Borit redefined traceability in 2013 by reviewing 101 articles on food traceability, stating that traceability is the ability to retrieve any or all information concerning an object throughout its lifecycle using recorded identifications (Olsen and Borit, 2013). An agricultural product traceability system is an important means of reducing information asymmetry. Agricultural product quality credit, as a quality-screening signal, helps achieve the survival of the fittest agricultural business entities. However, most current research on agricultural product traceability focuses on enhancing traceability and trust using blockchain technologies (Salah et al., 2019; Demestichas et al., 2020; Kamble et al., 2020; Prashar et al., 2020; Yang et al., 2021). Additionally, COVID-19 has driven the concept of multi-modal certification, encompassing both mandatory and voluntary traceable animal welfare certifications (Giannetto et al., 2023). Survey data indicate that ~47% of Mexican consumers are willing to pay a premium for pork produced with animal welfare considerations (Giannetto et al., 2023). The COVID-19 pandemic has significantly heightened consumer attention to traceable food safety and animal welfare, contributing to advancements in China's food industry toward higher standards. Studies show that consumers exhibit the highest preference for pork with high-level traceability information, followed by pork associated with health benefits and local production, underscoring a focus on food safety (Chen et al., 2021). Further research indicates that COVID-19 has increased consumer concerns about food safety, particularly in meat purchases, with risk perception notably elevated. Compared to previous studies, consumer willingness to pay for food safety attributes, such as BSE testing and traceability, has also markedly increased (Meixner and Katt, 2020).

The credit evaluation system is also a key link for eliminating information asymmetry among stakeholders in the circulation of agricultural products (Mohan, 2006; Mao et al., 2018). Therefore, under emerging conditions, constructing a "credit evaluation + traceability system" coupled regulation framework (i.e., a traceability system with additional quality credit information and a credit mechanism that enables traceability queries) can facilitate government contract regulation and market reputation incentives, thereby effectively improving the regulatory efficiency of agricultural product safety. This approach represents an urgent and feasible concept and mechanism for regulating agricultural product quality and safety.

The coupled regulation of business entity credit evaluation and agricultural product traceability systems is not a simple superposition of the credit mechanism and traceability system but an organic integration of the two. Specifically, it is necessary to develop a traceability system with additional quality credit information and a credit mechanism that enables traceability queries. Both traceability systems and credit evaluations can ensure the quality and safety of agricultural products through government contract regulations and market reputation incentives. However, quality information that can be queried through a traceability system typically only achieves the effect of traceability, mostly post-event traceability, which is insufficient for product quality screening. Therefore, the role of government contract regulation is mainly played through traceability accountability, which is not conducive to utilizing market reputation incentives fully. Credit evaluation, with a relatively comprehensive and reliable set of quality indicators, can distinguish the quality of business entities and products, which can better strengthen government supervision; however, it does not effectively convey quality credit information to consumers, making it difficult to utilize market reputation incentives. The effectiveness of the coupled regulation of business entity credit evaluation and agricultural product traceability systems is mainly reflected in the following factors. First, shifting regulation more directly from products to people makes it easier to regulate responsible entities. Second, making product quality and business entity credit known to consumers improves the symmetry of quality information. Third, better post-event traceability accountability and recall of problematic agricultural products, and pre-event assessment, discovery, and

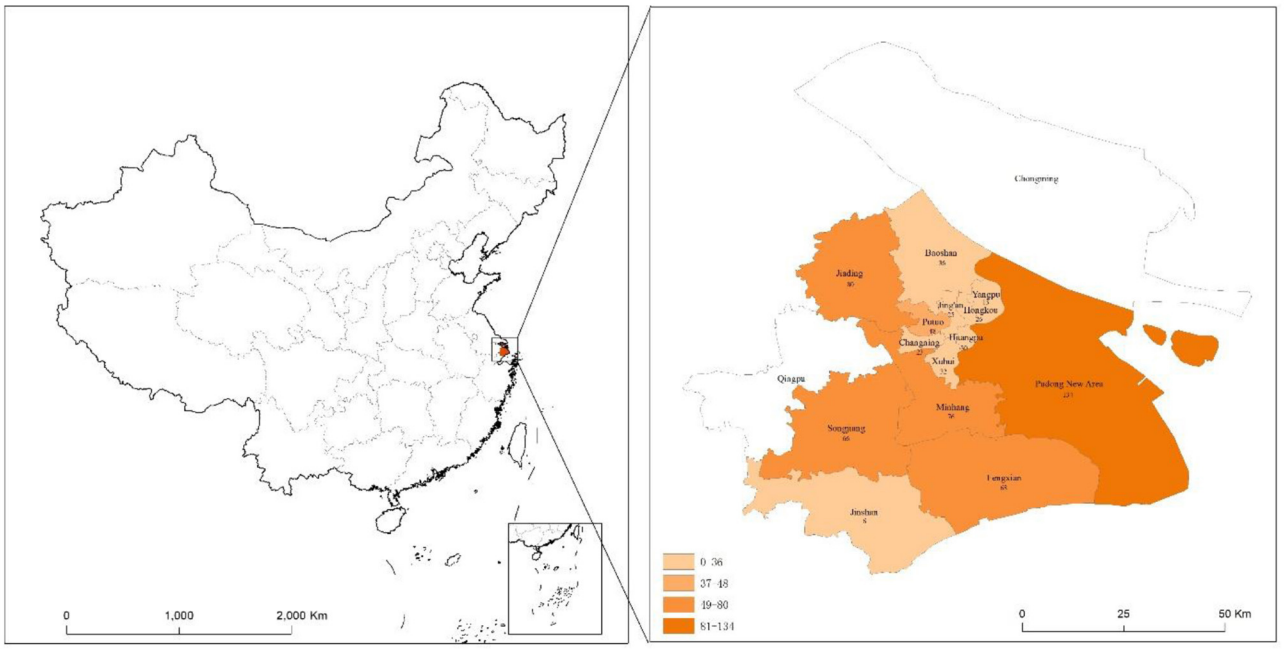

FIGURE 1
Distribution of survey samples.

prevention of agricultural product quality and safety risks can be achieved. Fourth, more refined market segmentation helps achieve premium pricing for high-quality products and avoid the "guilt by association" effect caused by the non-compliant behavior of a single business entity. Additionally, agricultural product quality certification systems such as HACCP and green food certification mainly target enterprises of a certain scale and high-end agricultural products, making it difficult to consider quality safety regulations for small farmers and low-end agricultural products that have higher risks. The "credit evaluation + traceability system" coupled regulation approach represents a strategy and mechanism that can cover all business entities, including small farmers.

3 Methodology

3.1 Data collection

Contingent valuation methods (CVM) have been studied and applied extensively (Holvad, 1999; Carson, 2000; Geleto, 2011; Kanayo et al., 2013; Samdin, 2018; Mutaqin and Usami, 2019). In this study, we used a CVM to investigate consumer WTP for credit-traceable agricultural products through a survey. Considering that many consumers have low awareness of credit-traceable agricultural products, information reinforcement and scenario descriptions were first provided to respondents (e.g., in the places where you often purchase pork, "credit-traceable agricultural products" and "ordinary agricultural products" are sold simultaneously). However, credit-traceable agricultural products track and record the quality information of the entire production process, including planting, packaging, and sales, as well as the quality and safety credit evaluation information of agricultural business entities. This traceability information is published on a government traceability system platform. Consumers can use the traceability code on a shopping receipt or product label to check quality safety information, including agricultural product certification (self-commitment to quality by agricultural producers) and the credit level of agricultural business entities (excellent, good, average, and poor) through query machines at purchase locations or online channels.

We considered pork as a representative agriculture product and adopted a dichotomous choice method to determine consumer WTP for credit-traceable pork. The dichotomous choice method only requires respondents to answer "willing" or "unwilling" to different prices of the product (i.e., asking respondents "Compared with ordinary pork, are you willing to pay an additional X yuan/kg for credit-traceable pork?"). Different bid prices (2, 4, 6, 10, 20, and 30 yuan/kg) were provided to the different subsamples to verify whether the proportion of willing responses decreased as the bid price increased. Among the 669 valid questionnaires, there were 111 questionnaires each for bid prices of 2, 4, 6, 10, and 20 yuan/kg, and 114 questionnaires for a bid price of 30 yuan/kg. The selection of subsamples for each bid price was random and distinct. It should be noted that in the actual questionnaire survey, the unit of bid price was a catty, which is a common unit of measurement in China.

The data analyzed in this study were obtained mainly from field surveys conducted in 15 districts of Shanghai (excluding Chongming) in October of 2020, resulting in 669 valid questionnaires. The distribution of the samples is presented in Figure 1. Survey participants were selected using random sampling and face-to-face interviews. Prior to the formal survey, personnel training and a pre-survey were conducted.

TABLE 1 Sample characteristics.

Item	Category	Frequency	Percentage
Gender	Male	352	52.62%
	Female	317	47.38%
Age	30 years and under	336	50.22%
	31–40 years	176	26.31%
	41–50 years	61	9.12%
	51–60 years	44	6.58%
	61 years and over	52	7.77%
Education level	Elementary school or lower	9	1.35%
	Middle school	41	6.13%
	Technical school or high school	68	10.16%
	College diploma	93	13.90%
	Bachelor's degree	262	39.16%
	Graduate degree	196	29.30%
Place of origin	Shanghai	340	50.82%
	Other provinces	329	49.18%
Average monthly household income	Below 10,000 yuan	179	26.76%
	10,000–50,000 yuan	229	34.23%
	60,000–100,000 yuan	70	10.46%
	110,000–150,000 yuan	62	9.27%
	Above 150,000 yuan	129	19.28%

The basic characteristics of the respondents are listed in Table 1. From a gender perspective, male respondents slightly outnumbered females, accounting for 52.62% of the sample. From an age perspective, those under 30 years accounted for 50.22% of the total sample, 31–40 years old accounted for 26.31%, 41–50 years old accounted for 9.12%, 51–60 years old accounted for 6.58%, and over 60 years old accounted for 7.77%. From an educational perspective, most respondents had a college degree or higher with 13.90% holding a college degree, 39.16% holding a bachelor's degree, and 29.30% holding a graduate degree. From a household registration perspective, 50.82% of respondents had a local Shanghai household registration. From an income perspective, 26.76% of the respondents had a monthly household income (after tax) of 10,000–30,000 yuan, 34.23% had an income of 10,000–50,000 yuan, 10.46% had an income of 60,000–100,000 yuan, 9.27% had an income of 110,000–150,000 yuan, and 19.26% had an income of over 150,000 yuan.

3.2 Econometric model

Consumer WTP for credit-traceable pork is a binary choice problem with options of either "willing" or "unwilling." This is a typical dichotomous choice model in which consumers make purchasing decisions based on the principle of utility maximization. In a market in which both regular pork and credit-traceable pork are available, if a consumer chooses to purchase credit-traceable pork, this option provides greater utility than regular pork. Based on this rationale, we constructed the following binary logit model and estimated the model using the Stata 13.0 software:

$$\ln\left[\frac{P(Y=1)}{1-P(Y=1)}\right] = a + bZ + cTP + \varepsilon \quad (1)$$

In this model, a is a constant term, b is the coefficient of the independent variable, and ε is an error term. TP denotes the bid price for credit-traceable pork and Z represents the factors influencing consumer utility, which affect purchasing decisions (as detailed in Table 2). Based on the model's estimation results, the average WTP for credit-traceable pork among consumers was calculated using the following formula (Zhou and Peng, 2006):

$$E(WTP) = -\frac{a + bZ}{c} \quad (2)$$

The independent variables and their definitions are presented in Table 2.

4 Results and analysis

4.1 Descriptive analysis of WTP for credit traceable agricultural products

Our survey revealed that among the 669 respondents, 60.69% primarily relied on the purchase location to determine pork quality and safety. Beyond location, 49.93% of the respondents made judgments based on appearance and smell. Only 322 and 232 people, representing 48.13 and 34.68% of the total sample, respectively, used certification or traceable labels to assess pork quality and safety. This indicates that these methods have not yet been widely adopted. A total of 488 consumers, accounting for 72.94% of the sample, have purchased agricultural products with information traceability codes.

As shown in Figure 2, the number of consumers willing to pay extra for credit-traceable pork decreased as the bid price increased. At a bid price of 2 yuan/kg, 94.59% of consumers were willing to pay an additional amount for credit-traceable pork. However, when the bid price rose to 30 yuan/kg, only 10.53% of the consumers were willing to pay the extra cost.

4.2 Factors influencing WTP for traceable pork

Our model was estimated using Stata 13.0 and the results are presented in Table 3. Based on the model's pseudo-R^2, likelihood ratio (LR), and the corresponding p-value, Pseudo $R^2 = 0.3362$, LR chi$^2 = 311.79$, Prob > chi$^2 = 0.0000$, it can be concluded that

TABLE 2 Definitions and summary statistics of variables.

Item		Definition	Value assignment	Mean	Standard deviation
WTP	WTP	What is your willingness to pay at the current bid price?	Willing = 1, Unwilling = 0	0.49	0.50
Price level	Bid price	Bid price: 2 yuan, 4 yuan, 6 yuan, 10 yuan, 20 yuan, 30 yuan (per Kg)	Actual values	12.08	10.00
Purchase experience	Purchase experience	Have you ever purchased agricultural products with traceability codes? ① Yes ② No	Yes = 1, No = 0	0.73	0.44
Trust level	Trust level	Do you believe that "agricultural products with traceability codes are safer in terms of quality"?	Strongly distrust = 1, slightly distrust = 2, neutral = 3, trust = 4, strongly trust = 5	3.88	0.86
Consumption Habits	Concern for Pork Safety	Do you typically pay attention to the quality and safety of pork when selecting it?	Not concerned = 1, slightly concerned = 2, neutral = 3, concerned = 4, very concerned = 5	3.92	0.99
	Confidence in pork safety	Are you confident in the quality and safety of the pork you purchase?	Not confident = 1, slightly confident = 2, neutral = 3, confident = 4, very confident = 5	3.61	0.95
	Pork quality determination based on certification label or traceability label	Do you rely on certification labels to judge the quality and safety of pork?	Yes = 1, No = 0	0.35	0.48
		Do you rely on traceability labels to judge the quality and safety of pork?	Yes = 1, No = 0	0.30	0.46
	Purchase location	Large supermarket	Yes = 1, No = 0	0.60	0.49
		Specialty store	Yes = 1, No = 0	0.15	0.36
		Farmers' market or wholesale market	Yes = 1, No = 0	0.54	0.50
		Online platform	Yes = 1, No = 0	0.16	0.37
	Proportion of pork consumption	What is the proportion of pork in your household's total consumption of meat and poultry?	Below 10% = 1, 10%−29% = 2, 30%−49% = 3, 50%−69% = 4, 70% and above = 5	2.55	1.17
	Average monthly pork purchase	What is your household's average monthly purchase of pork? (in Kg)	0–2 = 1, 2.1–4 = 2, 4.1–6 = 3, 6.1–8 = 4, 8.1 and above = 5	2.52	1.24
	Purchase price	What is the typical price range of pork your household purchases (in yuan/Kg)?	15 yuan and below = 1, 16–20 yuan = 2, 21–25 yuan = 3, 26–30 yuan = 4, 31 yuan and above = 5	3.58	1.16
	Local pork purchase habit	Do you intentionally choose to buy Shanghai local brand pork?	Yes = 1, No = 0	0.70	0.46
Individual characteristics	Gender	① Male ② Female	Male = 1, Female = 0	1.47	0.50
	Age	Age: in years	Actual value	34.71	14.08
	Education level	① Elementary school or below ② Middle school ③ Technical school/high school ④ College diploma ⑤ Bachelor's degree ⑥ Graduate degree	Assigned values from 1 to 6 based on education level, from high to low	4.71	1.24
	Place of origin	① Shanghai ② Other provinces	Shanghai = 1, Others = 0	1.49	0.50
Household characteristics	Number of household members	Total number of household members (living together)	Actual value	3.57	2.67
	Children	Are there any children (15 years old or younger) in your household? ① Yes ② No	Yes = 1, No = 0	1.64	0.48
	Elderly	Are there any elderly members (60 years old or older) in your household? ① Yes ② No	Yes = 1, No = 0	1.70	0.46
Income level	Income level	What is your household's average monthly income (after tax)?	Below 10,000 yuan = 1, 10,000–30,000 yuan = 2, 40,000–50,000 yuan = 3, 60,000–100,000 yuan = 4, Above 100,000 yuan = 5	2.60	1.46

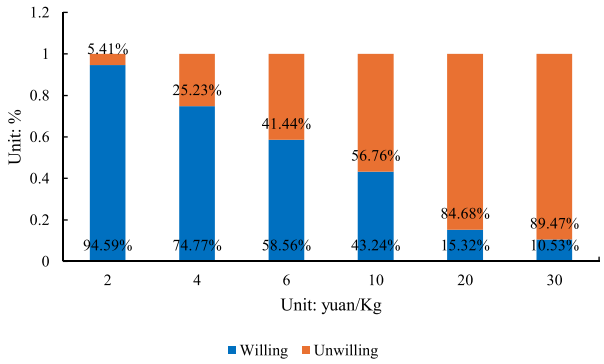

FIGURE 2
Consumer WTP at different bid prices (unit: yuan/kg).

the model demonstrates a good fit and that the variables are of reasonable significance.

The estimation results reveal that nine variables significantly affect consumer WTP for traceable pork: bid price, purchase experience, level of trust, concern for pork safety, confidence in pork safety, purchase from specialty stores, preference for local pork, gender, and education level. First, the bid price has a significant negative impact on consumer WTP for traceable pork, meaning that as the bid price increases, the likelihood of consumers purchasing traceable pork decreases. From a marginal effect perspective, for each increase in bid price, the probability of consumers being willing to purchase traceable pork decreases by an average of 0.05. Therefore, the demand curve for credit-traceable pork is likely downward sloping, meaning consumer demand decreases as the price of credit-traceable pork rises. This explanation has been added to the main text. Second, purchase experience positively and significantly influences consumer WTP for traceable pork. Consumers who purchase agricultural products with traceability codes are more willing to pay an additional price for traceable pork. The marginal effect reveal that compared with consumers who have not purchased products with traceability codes, consumers with such experience exhibit a 0.15 increase in WTP for traceable pork on average.

The level of trust in traceability codes also has a significant positive impact on WTP. The more consumers trust that "products with traceability codes are safer than those without," the more willing they are to pay additional prices for traceable pork. The marginal effect indicates that for each increase in trust level, the likelihood of purchasing traceable pork increases by 0.03 on average.

Consumer concerns and confidence regarding the safety of the pork they purchase negatively and significantly affect their WTP for traceable pork. The lower the concern and confidence levels, the higher the likelihood that consumers will be willing to pay an additional price for traceable pork. To some extent, this also indicates that consumers have greater confidence in the safety of traceable pork. The marginal effect reveals that for each decrease in concern and confidence levels, the likelihood of being willing to pay more for traceable pork increases by 0.03 on average. Consumers who purchase pork from specialty stores are more willing to pay extra for traceable pork because they tend to have higher safety requirements. The marginal effect indicates that compared with those who do not purchase from specialty stores, the likelihood of paying extra for traceable pork increases by 0.10 on average. Consumers who deliberately choose to buy local Shanghai pork are more likely to pay more for traceable pork. The marginal effect reveals that compared with those who do not deliberately choose local pork, the WTP for traceable pork of consumers who do deliberately choose local pork increases 0.06 on average.

Finally, gender and educational level also influence consumer WTP. Male consumers and those with lower educational levels are more likely to be willing to pay extra for traceable pork.

TABLE 3 Model estimation results.

Variables	Coefficient	*z*-value	Marginal probability
Bid price	−0.319***	−10.22	−0.05
Purchase experience	0.973***	4.02	0.15
Level of trust	0.221*	1.71	0.03
Concern for pork safety	−0.217*	−1.85	−0.03
Confidence in pork safety	−0.231*	−1.89	−0.03
Certification label	0.089	0.38	0.01
Traceability label	−0.182	−0.74	−0.03
Large supermarket	−0.148	−0.69	−0.02
Specialty store	0.640**	2.09	0.10
Farmers' market or wholesale market	−0.052	−0.24	−0.01
Online platform	−0.177	−0.62	−0.03
Proportion of pork consumption	0.052	0.53	0.01
Average monthly purchase volume	0.125	1.31	0.02
Purchase price	0.086	0.93	0.01
Preference for local pork	0.419*	1.84	0.06
Gender	0.472**	2.27	0.07
Age	0.006	0.65	0.00
Education level	−0.203**	−2.19	−0.03
Place of origin	−0.101	−0.44	−0.02
Household size	0.005	0.10	0.00
Presence of children	−0.048	−0.20	−0.01
Presence of elderly	0.149	0.60	0.02
Income level	0.067	0.92	0.01
_cons	0.755	0.57	−0.05
Pseudo R^2: 0.3362			
LR chi^2: 311.79			
Prob > chi^2: 0.0000***			

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

4.3 Group differences in WTP for traceable pork

Using the formula for calculating average WTP, we determined that consumers in Shanghai are willing to pay an additional 8.48 yuan/kg for traceable pork, which translates to 8.48 yuan per kilogram. In addition to calculating the average WTP for all consumers, we also examined and calculated the differences in WTP among various consumer groups, including consumers with different purchase experience, trust in traceability codes, concern and confidence in pork safety, proportions of pork consumption, gender, education level, and income, as shown in Table 4. Although some variables may not significantly impact WTP, there are still considerable differences in the WTP for traceable pork.

The results indicate that consumers who have purchased products with traceability codes are willing to pay an additional 9.18 yuan/kg for traceable pork, which is slightly higher than the value for those who have not. Consumers with varying levels of trust in traceability codes exhibit significant differences in their WTP. Specifically, consumers who "do not trust at all" are only willing to pay an additional 5.66 yuan/kg, whereas those who "strongly believe" in the safety of products with traceability codes are willing to pay an additional 10.64 yuan/kg, a difference of 6.98 yuan/kg. As trust levels increase, consumer WTP also increases.

Consumers who are not at all concerned about the safety of the pork they purchase are willing to pay an additional 7.82 yuan/kg for traceable pork, those who are slightly concerned are willing to pay an additional 6.60 yuan, those with moderate concern are willing to pay an additional 8.30 yuan, those who are fairly concerned are willing to pay an additional 8.20 yuan, and those who are very concerned are willing to pay an additional 9.36 yuan. Overall, the more concerned consumers are about pork safety, the more willing they are to pay for traceable pork.

Consumers who deliberately choose to buy local Shanghai pork have an average WTP for traceable pork that is 2.02 yuan/kg higher than those who do not deliberately choose local pork. Additionally, there were no significant differences in the average WTP for traceable pork across gender, education level, place of origin, or household monthly income level.

5 Main conclusions and policy implications

This study considered pork as an example product and utilized survey data from 669 consumers across 15 districts of

TABLE 4 Differences in average WTP among consumer groups based on various variables.

Influencing factor	Variable category	Frequency	Proportion	WTP level (Yuan/Kg)
Purchase experience	Purchased	488	72.94%	9.18
	Not purchased	181	27.06%	8.02
Level of trust	Very untrusting	6	0.90%	5.66
	Slightly untrusting	36	5.38%	6.62
	Moderately trusting	148	22.12%	7.72
	Fairly trusting	319	47.68%	8.00
	Very trusting	160	23.92%	10.64
Concern for pork safety	Not concerned at all	11	1.64%	7.82
	Slightly concerned	50	7.47%	6.60
	Moderately concerned	143	21.38%	8.30
	Fairly concerned	245	36.62%	8.20
	Very concerned	220	32.88%	9.36
Local pork purchasing habit	Intentionally purchase local pork	467	69.81%	9.08
	Do not intentionally purchase local pork	202	30.19%	7.06
Gender	Male	352	52.62%	8.14
	Female	317	47.38%	8.84
Education level	Vocational/high school or above	118	17.64%	8.36
	Associate degree or above	551	82.36%	8.50
Income level	30,000 Yuan or below	408	60.99%	8.00
	Above 30,000 Yuan	261	39.01%	9.22
Household registration	Shanghai	340	50.82%	8.38
	Other Provinces	329	49.18%	8.58

Shanghai. By employing the CVM and a binary logit model, we empirically analyzed consumer WTP for traceable pork products and identified influencing factors. Previous relevant studies (Yue et al., 2021; Ngo et al., 2023), which primarily highlight people's willingness to pay a premium for vegetables or meat during the pandemic. In contrast, our research focuses on consumers' willingness to pay for traceable pork during COVID-19, with an emphasis on their concerns regarding pork quality and safety, as well as their willingness to purchase traceable pork during the pandemic.

Additionally, we calculated the average WTP for traceable pork. Our main findings are summarized below.

Purchase experience: among the respondents, 72.94% reported having purchased agricultural products with traceability codes. Impact of bid price: after strengthening information regarding the agricultural product traceability system, we observed that as the bid price increased, the number of consumers willing to pay extra for traceable pork decreased. For example, 94.59% of consumers expressed WTP extra when the bid price was 2 yuan/kg but this proportion dropped to 10.53% when the bid price reached 30 yuan/kg. Key influencing factors: our model analysis revealed that nine variables significantly affected consumer WTP for traceable pork: bid price, purchase experience, trust level, concern for pork safety, confidence in pork quality, purchasing from specialty stores, local pork purchasing habits, gender, and education level. On average, consumers were willing to pay an additional 8.48 yuan/kg for traceable pork compared with regular pork. Although some variables had an insignificant impact, the WTP for traceable pork still exhibited considerable variation across different consumer groups.

Our findings suggest that under emerging conditions, constructing a "credit evaluation + traceability system" coupled regulatory framework is essential. By enabling the credit traceability of responsible entities, such a system not only enhances government regulatory effectiveness but also leverages market reputation, thereby improving the overall efficacy of agricultural product safety regulations. This approach represents a novel and urgent strategy for the regulation of agricultural product quality and safety.

The conclusions of this study provide several important insights into accelerating the development of an agricultural product traceability system.

Streamlining traceability processes: it crucial to track and record quality information throughout the entire production process, including cultivation, packaging, processing, storage, and sales, as well as the quality and safety credit evaluation information of agricultural business entities. This process includes making the quality information and credit ratings of agricultural business entities traceable and searchable, including agricultural product compliance certificates. Establishing a dynamic evaluation system: relevant information such as administrative permits, penalties, quality certifications, and supervision inspections of agricultural production entities should be integrated into the evaluation system and traceability platform database. A dynamic evaluation system should be established with periodic updates of evaluation results. Differentiated management should be applied at different levels, considering factors such as inspection frequency, penalty severity, eligibility for agricultural projects, and access to agricultural subsidies. Enabling consumer-end traceability queries: the comprehensive implementation of an edible agricultural product compliance certificate system should be ensured. Agricultural production and business entities should be encouraged to conduct self-inspections using rapid testing technologies for agricultural product quality and safety or to commission third-party sampling inspections. The relevant information should be included in compliance certificates. Certificates should also feature QR codes based on the agricultural product traceability system, allowing consumers to scan codes to view product information, agricultural operations, test results, and the quality and safety credit rating of the agricultural business entity, thereby achieving full traceability from farm to table. Promoting "one product, one code": a traceability information QR code should be printed on each product label, enabling consumers to scan the code before purchase to access production information, compliance certificate details, and the quality credit information of the business entity, thereby fully safeguarding consumers' right to know. Enhancing public awareness: through platforms such as news media, it is important to strengthen the promotion and reporting of agricultural product traceability systems. This will increase public awareness of the traceability system, heighten sensitivity to traceability information, and enhance consumer awareness of how to access this information.

Data availability statement

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

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/ participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

ZL: Conceptualization, Funding acquisition, Investigation, Supervision, Writing – original draft, Writing – review & editing. TF: Conceptualization, Data curation, Investigation, Writing – original draft, Writing – review & editing. CL: Conceptualization, Formal analysis, Supervision, Writing – review & editing. SW: Data curation, Formal analysis, Software, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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