Consumer intentions to purchase organic pasta with blockchain-based traceability

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Highlights

- Subjective norms strongly influence purchase intentions for blockchain-traceable pasta.
- Perceived control impacts adoption by facilitating access to blockchain-verified products.
- Trust in certifications does not significantly impact blockchain-based purchase intentions.
- Positive attitudes toward the technology drive blockchain adoption in food traceability.
- Attitude towards traceability does not positively influence the purchase intention of pasta traced with blockchain technology

Abstract

The increasing complexity of global food supply chains has heightened consumer concerns about food safety, quality and authenticity, and triggered a growing demand for transparency-enhancing technologies such as blockchain. This study examines the factors influencing consumers' intention to purchase organic pasta with blockchain-based traceability using an extended Theory of Planned Behaviour (TPB) framework. In addition to the traditional TPB constructs, the study incorporates trust in quality certifications and attitudes towards blockchain technology to provide a comprehensive analysis of decision-making processes. The data was collected via an online survey of 190 Italian respondents and analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The results show that subjective norms, perceived behavioural control and attitudes towards technology significantly influence purchase intentions, while trust in quality certifications and attitudes towards the traceability of blockchain do not significantly influence purchase intention.. These findings suggest that while blockchain technology is recognised for its potential to improve transparency, its practical benefits are not yet fully understood or appreciated by consumers. This study contributes to the literature on consumer behaviour in the agri-food sector and provides practical insights for policy makers and marketers to promote blockchain-based traceability systems.

Keywords: consumer purchase intention; theory of planned behaviour (TPB); organic pasta; blockchain-based traceability; food fraud, technology

1. Introduction

In the food sector, issues such as traceability and food safety have become central to the supply chain, with producers increasingly prioritising these aspects over other objectives (Alshehri, 2023). This shift goes hand in hand with an emerging paradigm shift in consumer demand. Consumers are now showing an increasing preference for products that are perceived as safer (Mahsun et al., 2023). This is evidenced by the fact that more and more consumers are expressing concerns about food safety and quality and, therefore, favour foods whose labels provide clear and accurate information about product characteristics (Lewis & Grebitus, 2016; Sadílek, 2019; Moruzzo et al. 2020; Kaczorowska et al. 2021). The European Parliament and the Council have also established quality certification for organic agri-food products through Regulation (EU) No 2018/848. According to this Regulation, organic products have been developed to respond to a specific market where consumers demand products whose production respects the environment and animal welfare, preserves biodiversity and contributes to rural development (Sampalean, et al., 2021). However, consumers cannot verify credence attributes and must therefore rely on the reliability of the manufacturer's or retailer's claims (Plasek and Temesi 2019). Credence attributes refer to product characteristics that consumers cannot directly verify before purchase and must rely on external assurances to assess their validity (Plasek and Temesi, 2019; Lassoued and Hobbs, 2015). In the context of food products, these attributes include factors such as organic certification, geographical origin, sustainability claims, and production methods (Fernqvist and Ekelund, 2014)

The credibility of these parties also depends on consumer trust in the food system, including the regulatory authorities responsible for ensuring food safety and compliance with food labelling regulations (Fernqvist and Ekelund 2014; Lassoued and Hobbs 2015; Meijer et al. 2021).

Trust is a multi-layered concept that is shaped by several factors, including the geographical and temporal distance between the parties involved, cultural norms, the institutional environment and historical events that influence perceptions of food safety and quality (Berg, 2004). Currently, consumer trust in the food system is uncertain, particularly in relation to transparency and authenticity (Frewer, 2017; Wu et al., 2021; Menon et al., 2021) and more generally in relation to perceptions of food safety (Macready et al., 2020; Meijer et al., 2021). The main cause of this trend is the inherent complexity of the food supply chain, which involves a multitude of parties and processes (Hassoun et al., 2020; Reitano et al., 2024) and can lead to food safety issues (Meijer et al., 2021). This decline in consumer confidence has significant consequences, such as the limited effectiveness of certifications and consequently a decrease in potential demand for products with credible attributes, such as origin, production process characteristics and product properties (Marozzo et al., 2022). From a public interest perspective, low trust has negative implications for sustainable development and public health policies that rely on traditional forms of certification to inform consumers about the nutritional and ethical value of products Kjærnes, 2006; Sapp et al, 2009; Hobbs and Goddard, 2015; Kaiser and Algers, 2017). Considering the above-mentioned characteristics of the agri-food production system, it is essential to develop a coherent management system adapted to its specific needs (Gardeazabal et al., 2023). In response to the prevailing concerns in the agri-food sector, a number of technological innovations have emerged to improve and strengthen food traceability. Among these, blockchain technology (BCT) has attracted much attention (Reitano et al., 2024). The emergence of cryptocurrencies has led to the popularisation of BCT, which can be defined as a decentralised and immutable register of information (Gupta and Sadoghi, 2019; Krzyzanowski, Guerra & Boys, 2022). In such a system, all subjects in the chain can access the recorded information at any time, but without the possibility to change a record (Tian, 2017; Zhao et al., 2019; Wünsche and Fernqvist, 2022). This function is suitable for meeting the specific requirements of the food industry and creating a reliable system for tracking the path of a food product from production to consumption. This will make it easier to ensure food safety (Saurabh & Dey, 2021; Mónica Martínez-

Castañeda & Fejoo, 2023) and has the potential to combat problems such as label tampering, counterfeiting of designations of origin and the introduction of substandard products (Ayan et al., 2022; Serra-Majem et al., 2020).

In the food sector, BCT seems to be a promising solution that could enable more transparency (see Javaid et al., 2021; Aldrighetti et al., 2021; Singh & Sharma, 2022; Vern et al., 2024). It is already being used to record all transactions between actors involved in the supply chain to ensure the transparency and traceability of products (see Kamilaris et al., 2019; Galvez et al., 2018). However, despite its potential, a fundamental factor is the understanding of the benefits attributed by consumers, as emphasised by Feng and colleagues (2020). Indeed, the widespread adoption of this technology depends on consumer perception and acceptance (Albertsen et al., 2020). As Singh et al. (2023) argue, the success of any technological innovation in the food sector is inextricably linked to consumer acceptance. In the consumer market, there is a growing willingness among consumers to adopt innovative technologies that facilitate access to comprehensive data on supply chain operations (Cozzio et al., 2023). In line with this premise, a study by Osei et al. (2021) hypothesises that consumers will adopt BCT technology if it can demonstrably improve food safety and quality.

Numerous studies have shown that BCTs have a positive impact on consumer purchasing decisions (Sander et al., 2018; Violino et al., 2019; Polenzani et al., 2020; Lin et al., 2022). However, other authors have pointed to a discrepancy between consumer perception and the actual value attributed to technology-specific information confirming that food has been traced with BCTs (Shew et al., 2022). Liu et al. (2023) investigated the relationship between consumer trust in the agri-food system and certification and showed a positive influence of high levels of trust on preferences for products with traceability and the use of BCTs. The influence of BCTs on purchasing decisions, especially for certified food has a significant impact on demand and thus contributes to the success of BCT-based systems. The comprehensive traceability information that this technology provides along the entire food supply chain represents significant added value for consumers.

Contini et al. (2023) have shown that BCT promotes a positive attitude towards consumer preferences and perceptions, thus increasing trust in the system due to satisfaction with the perceived quality of the certified products. As Mazzù et al. (2021) note, BCT-based traceability also requires the involvement of certification and regulatory bodies in the supply chain system. This helps to increase consumer confidence in the reliability of the information provided, while facilitating access to comprehensive food information, including declarations from food supply chain actors, such as organic certification, chemicals used and agricultural practises. Although the technological potential of BCT has been demonstrated in previous studies (Kamilaris et al., 2019; Galvez et al., 2018), there is still little research on consumer perceptions and intentions. In particular, there is a need to investigate how consumers evaluate BCT-enabled traceability in combination with established constructs such as trust, attitudes and perceived ease of use. In recent literature, theoretical frameworks such as the Theory of Planned Behaviour (TPB) have been used to analyse consumer intentions to adopt blockchain in food systems. The studies by Dionysis et al. (2022) and Lin et al. (2021), for example, highlighted the importance of subjective norms and perceived behavioural control. However, the results regarding attitudes towards BCT were inconclusive. Contini et al. (2023) emphasised the potential of BCT to increase trust, but their results show a discrepancy between consumer trust in traditional certifications and the added value of blockchain traceability.

To fill this gap, this study investigates which factors influence consumers' intention to buy organic pasta with blockchain-based traceability.

We conducted an online questionnaire with a sample of 190 Italian respondents to investigate their behaviour towards organic pasta, as it already plays an important role in several practical applications of BCT. Using the extended TPB model, we were able to identify the factors that influence consumption. Constructs such as attitude, subjective norms and perceived behavioural control were complemented by trust in quality certifications and attitudes towards technology to increase the

predictive power of the model. Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to analyse the relationships between the constructs and validate the research hypotheses.

2. Theoretical framework and research hypotheses development

The Theory of Planned Behaviour (TPB) is a theoretical model from the field of psychology with particular significance for predicting and changing human behaviour, especially in connection with the use of technology (Ajzen, 2020; Fleiß et al., 2024; Cudjoe et al., 2023). The TPB postulated by Ajzen (1980) is based on the assumption that individual behaviour depends on three basic elements: the individual's attitude, subjective norms or social pressure and perceived behavioural control. The TPB has been used in the consumer decision-making literature in a variety of contexts (Lin, 2007), including in the context of food choice, where it has been used to identify the motivational factors underlying the choice of one product over another (Nardi et al., 2019; Sogari et al., 2024) and to predict consumers' behaviour and intentions towards organic products (Armitage and Conner, 2001). The TPB is based on the idea that a person's behaviour depends on their intention to perform that behaviour. Behavioural intention is the result of the interaction of three factors:

1) Attitude (ATT): represents a person's inclination to perform a certain action. It is a person's opinion or judgement about adopting or performing a particular behaviour based on their values, beliefs and previous experiences with that behaviour. A positive attitude leads to a greater likelihood of behaving consistently with one's intention.

2) Subjective norms (SN): refers to the influence of other people's thoughts and attitudes towards a particular behaviour. In other words, it is the social pressure to perform or avoid a certain action, which may result from the expectations, encouragement or opinions of others.

3) Perceived Behavioural Control (PBC): refers to the perception of a person's ability to perform an action or the perception of the difficulty or ease of a particular behaviour depending on certain factors.

Several studies have investigated consumers' intention to buy products tracked with a blockchain-based system. In the study by Dionysis et al. (2022), the factors influencing the purchase intentions of coffee consumers considering coffee products that can be tracked with a blockchain-based tracking system are analysed using the TPB model. The original TPB model was extended to include additional constructs such as trust, past habits and environmental protection. The study contributes to the literature by providing insights into the factors that influence consumers' purchase intentions and shows that attitude towards coffee that is traceable with a blockchain-based traceability system, subjective norm and perceived behavioural control are positively associated with purchase intention. The study by Lin et al. (2021) also utilised the TPB to investigate the factors influencing Chinese consumers' intentions towards blockchain food traceability technology to ensure the food safety and quality of Chinese organic food. The study proposed an integrated conceptual framework combining two established theoretical models: the TPB and the informational success model (ISS). The study found that attitude and perceived behavioural control significantly and positively influence intention to use blockchain adoption, while subjective norms are positively but not significantly correlated with intention to use.

The work of Menozzi et al. (2015) analyses consumer attitudes and behaviour towards traceable food to explain the intention to buy traceable food using TPB. The results show that the predictive power of the TPB model increases significantly when new variables are added: habits, trust, past behaviours and socio-demographic variables. The results show that attitudes and trust influence the purchase intention for traceable food products.

Prisco et al. (2022) present an integrated approach that combines the TAM (Technology Acceptance Model) and the TPB (Theory of Planned Behaviour) and adds as benefits the additional factors "efficiency and safety", "reduced costs" and "quality of customer service" perceived by companies adopting blockchain technology. The results show that attitude and perceived behavioural control are the most important predictors of intention to adopt blockchain, while perception of benefits is the

most important predictor of attitude. In addition, subjective norms were found to have a positive effect on behavioural intention, while the effect of perceived ease of use on attitude was not significant.

In their study, Liu et al. (2023) explored the association between consumer trust in agricultural and food systems and the impact of certifications. Their results showed a positive correlation between high consumer trust and a preference for products with certificates of origin and the use of BCTs. The influence of BCTs on consumer purchasing decisions, especially for certified food, is an important factor influencing demand and thus the success of BCT-based systems. When investigating the relationship between trust in the food system and certifications, it was found that a high level of trust positively influences preferences for PDO and BCTs, while it has a less pronounced effect on preferences for organic certifications (Contini et al., 2023). The absence of a notable interaction between the degree of trust in the food system and the preference for organic certification can be attributed to the finding that such a preference does not rely on the degree of trust in the food system in general. Rather, it is determined by the alignment of values among the various actors involved in the organic supply chain (Thorsøe, 2015). This trust is reinforced by consumer satisfaction with the quality of the products (Ladwein and Romero, 2021) and is linked to the organic certification logo (Janssen and Hamm, 2012).

Based on the analysis of previous literature, the TPB (Ajzen, 1991) was chosen as the conceptual model for this study. However, this study aims to improve the predictive power of the TPB. In addition to the original items of the TPB, such as attitude, subjective norms and perceived behavioural control, additional constructs are introduced: trust in quality certification and attitude towards technology. Based on the above literature and theory, the following hypotheses are formulated. To avoid verbosity, the indicators in the table are presented in capital letters. See Table 1 below for details.

Table 1. Hypotheses and paths

Hypotheses	**Path**

H1: Subjective norms positively affects the intention to purchase pasta traced with blockchain technology (SN)	SN→INT
H2: Perceived behavioral control positively affects the intention to purchase pasta traced with blockchain technology (PBC)	PBC→INT
H3: Attitude towards traceability positively affects the intention to purchase pasta traced with blockch2ain technology (ATT)	ATT→INT
H4: Trust in quality certifications positively affects the intention to purchase pasta traced with blockchain technology (TQC)	TQC→INT
H5: Attitude towards technology positively affects the intention to purchase pasta traced with blockchain technology (TEC)	TEC→INT

3. Data and Method

3.1. Data collection

The data collection tool consists of an online questionnaire developed on the Qualtrics platform to explore consumer intentions regarding organic pasta tracked through an innovative traceability system. The design of the questionnaire is based on the TPB presented in the previous section. The TPB approach effectively identifies factors influencing decision-making and perceived risk, making it suitable for the focus of this study on traceable products. The questionnaire aims to capture the determinants influencing consumer preferences and behaviour by incorporating the key TPB constructs. The questionnaire was divided into several sections, each designed to collect specific information related to the objectives of the study.

1) Introduction: This section provided a general overview of the study and ensured that participants kept their responses confidential.

2) TPB constructs: This section explored participants' intentions and the key dimensions of the TPB model: attitude, subjective norms and perceived behavioural control.

- The intention construct captures the likelihood that consumers will consider purchasing pasta with blockchain traceability once it is available.

- The subjective norms construct measures the influence of social factors, including family, academia, media, and retail, on consumers' decision to purchase pasta with blockchain traceability.

- The construct of perceived behavioural control assesses consumers' perceptions of the ease or difficulty of accessing and using products with blockchain traceability. This includes finding such products in shops and using the relevant technology, which is critical to understanding potential barriers to adoption.

- The attitudinal construct captures consumer perceptions of the benefits associated with using blockchain technology for food traceability and focuses on aspects such as safety, transparency, authenticity and production standards.

The design of these questions was guided by previous research such as Dang & Tran (2020), Dionysis et al. (2022) and Menozzi et al. (2015) to ensure that all key variables were comprehensively addressed. A 5-point Likert scale was used, ranging from 'strongly disagree' to 'strongly agree'," so that participants could express a nuanced opinion on each statement.

3) Consumer Trust in Quality Certification: Trust in quality certification is an important factor that influences consumers' confidence in the safety and authenticity of products. This construct assesses the extent to which consumers trust the quality certification information provided by companies. This block focused on assessing trust in organic food producers and sellers, drawing on the work of Li et al. (2023).

4) Attitudes towards technology: The questions in this section were organised based on the Technology Readiness Index (TRI), a scale validated by Parasuraman (2000). This index measures consumer attitudes toward technology in four dimensions: Optimism (OPT), Innovativeness (INN), Discomfort (DIS), and Insecurity (INS). By including these dimensions, the survey was able to assess how technological readiness influences consumer acceptance of traceable systems. Respondents rated

their level of agreement on a 5-point scale, which allowed for an in-depth analysis of their comfort and adaptability to new technological applications.

5) Socio-demographic questions: In the last section, demographic information such as age, gender, education level and income were collected.

The scales for the TPB constructs and the Technology Readiness Index were adopted from previous studies to ensure their validity and reliability. The use of established scales in the study ensured that the constructs measured accurately reflected the concepts they were intended to assess.

Table 2 shows the latent variables and items in detail.

Variable	Items
Intention (INT)	1. When blockchain-traceable pasta becomes available, I intend to buy it
	2. When blockchain-traceable pasta becomes available, I will look for it and consider buying it
	3. When blockchain-traceable pasta is available, I am inclined to buy it
Subjective Norms (SN)	1. I would buy pasta tracked via blockchain technology because my partner, family and friends approve it
	2. I would buy pasta tracked via blockchain technology because scientists are in favour
	3. I would buy pasta tracked via blockchain technology because the media (TV radio, social media) is in favour
	4. I would buy pasta tracked via blockchain technology because the food manufacturers and supermarkets promote it
Perceived Behavioural Control (PBC)	1. I feel able to find blockchain-tracked food products in shops easily
	2. I think it is easy to use apps or online tools to verify food traceability via blockchain
	3. I think it is easy for me to follow the food production chain thanks to blockchain
Attitude toward BCT (ATT)	1. With the use of blockchain, organic pasta traceability information is more secure
	2. The origin of organic pasta tracked with blockchain traceability is always transparent
	3. Organic pasta information with blockchain traceability is more authentic
	4. Organic pasta with blockchain traceability will meet higher production standards
Trust toward Quality Certifications (TQC)	1. Companies always comply with quality certification regulations
	2. Companies provide consumers with transparent information on quality certification
	3. Quality-certified product information is always truthful
	1. I am optimistic about the innovative impact of technology

Attitude toward Technology (TEC)	2. I feel at ease to become familiar with technology
	3. I believe that the adoption of technology can generate a significant improvement in transaction and information security
	4. I find innovative technology to be mentally stimulating

The online questionnaire was administered to a sample of Italian respondents to gain insight into the factors that influence consumer behaviour. The survey was distributed online via the most popular social networking platforms (WhatsApp, Instagram and Facebook) to maximise reach and engagement. These platforms facilitated efficient data collection across all social networks and allowed for broader geographic and demographic representation. The survey was available on social media platforms from 30 October 2023 to 28 February 2024. During this period, participants were able to complete the questionnaire at their leisure. A total of 251 responses were collected, of which 190 were completed. A widely used procedure for estimating the minimum sample size in PLS-SEMs is the "tenfold rule" (Hair et al., 2011), which assumes that the sample size should be greater than 10 times the maximum number of inner or outer model terms that point to a latent variable in the model. PLS-SEM is advantageous as it does not impose strict assumptions about data distribution and can provide reliable results even when working with limited sample sizes by maximizing explained variance and minimizing estimation bias (Russo & Stol, 2021).

A combination of a random and snowball system was used to recruit participants. This approach was chosen for its practicality, as it enabled the efficient collection of responses from easily accessible individuals and facilitated the expansion of the research area and access to larger social networks. The random sample initially enabled rapid distribution of the survey, with the questionnaire accessible and fillable online and a particular focus on social media users.

3.2. Data analysis

The data analysis was conducted using the softwere Stata 18.5. Structural equation modelling (SEM) was used to examine the extended theoretical framework and test the hypotheses. SEM combines various multivariate analysis methods that facilitate the investigation of multiple interactions between several latent variables (Berki-Kiss & Menrad, 2022). It is widely used in the social sciences,

especially in the field of psychology. In this study, the partial least squares (PLS) structural equation model (SEM) was utilised. PLS-SEM is a statistical tool that has gained popularity among researchers who use it to analyse empirical data and evaluate different relationships simultaneously (Hair et al., 2019). The applications of covariance-based SEM (CB-SEM) and partial least squares SEM (PLSSEM) are complementary, rather than competitive (Marcoulides & Saunders, 2006). PLS-SEM is more effective than CB-SEM for analysing complex cause-effect relationships between multiple latent variables (Sarstedt et al., 2016). In addition, PLS-SEM provides reliable results even with relatively small sample sizes compared to covariance-based SEM. Furthermore, Hair et al. (2011) suggested that PLS-SEM is the optimal approach when research aims to identify causal relationships with unidentified potential variables that influence individuals' multidimensional behaviour and intentions. The process consists of two steps. These include the structural model (inner model) and the measurement model (outer model). The structural model evaluates the development of theories and hypotheses, while the reliability and validity of the constructs are evaluated using the measurement model (Russo & Stol, 2021).

4. Results

Table 3 contains the most important socio-demographic indicators. In the study sample, men (41%) and women (48%) were almost equally distributed. The largest age groups were 30-39 (33%) and 40-49 (29%), followed by those over 60 (22%). The youngest group comprised only 16% of participants. It is noteworthy that there were no people between the ages of 50 and 59.

The survey participants have a high level of education: the vast majority (84%) have a university or postgraduate degree. Only a small percentage (14%) have a high school diploma, and even fewer (2%) have completed middle school. None of the respondents reported having completed primary school. Most respondents (46%) were white-collar workers, followed by those working in businesses and public institutions (31%). A smaller proportion (16%) were unemployed and only 7% were students. In terms of income, the majority of participants (60%) reported an income of between €0

and €26,000. A smaller percentage (21%) earned more than 26,001 euros. Interestingly, 18% of participants stated that they had no income.

Table 3. Socio-demographic characteristics

	Detail of respondents	Percentage (%)
Gender	Male	41
	Female	48
	Other genders	6
	Prefer not to answer	5
Age	19-29	16
	30-39	33
	40-49	29
	50-59	0
	Over 60	22
Education	Elementary school	0
	Middle school	2
	High school	14
	College degree	31
	Post-degree (master, PhD..)	53
Occupation	Enterprise and public institution	31
	Employee	46
	Not employed	7
	Unemployed	4
	Retired	5
	Student	7
Income level (Euro / month)	0 €	18
	From 0 to 10.000 €	33
	From 10.001 to 26.000€	27
	From 26.001 to 55.000€	7
	From 55.001 to 75.000€	4
	From 75.001 to 120.000€	2
	>120.000€	8

The measurement model was assessed on the basis of convergent and discriminant validity. Convergent validity refers specifically to the extent to which the indicators of the variables accurately indicate and measure them and to which other measures of the same variables correlate appropriately (Bani-Khalid et al., 2022). To determine the convergent validity of the measurement model, we assessed the loadings of the indicators, the average variance extracted (AVE) and the composite reliability (CR) as well as Cronbach's alpha. According to the literature, the values for Cronbach's

alpha and composite reliability (CR), average variance extracted (AVE) and the loadings of the indicators must be higher than 0.70, 0.70, 0.5 and 0.70, respectively (Khan et al., 2023; Lin et al., 2021; Rubel et al., 2021). Accordingly, the loadings of the indicators were examined at in the first stage.As shown in Table 4 in the final measurement model, all indicator loadings exceed the threshold of 0.70. It means that the construct explains over half of the variance of the indicator. Therefore, acceptable item reliability is provided. Moreover, Cronbach's alpha and composite reliability are typically used to evaluate internal consistency reliability (Hair et al., 2019). As Table 4 shows all composite reliability and Cronbach α values are higher than 0.70, as it suggests that the elements of the same latent variable are similar.

The total mean of the squared loadings of the items associated with the construct is represented by the Average Variance Extracted (AVE) (Russo & Stol, 2021) was used to evaluate convergent validity. The Table 4 displays that theaverage variance extracted (AVE) from each latent variable is higher than 0.5. it means that the construct explains more than half of the variance of its items. In summary, Table 4 demonstrates that the standardized loadings, Cronbach's alpha , CR , AVE are all higher than the values recommended by the literature. Therefore, convergent validity was confirmed based on the results.

Table 4. Reliability and validity tests

Latent Construct	**Items**	**Standardized loadings**	**Cronbach's alpha**	**CR**	**AVE**
Intention (INT)	INT1	0.898	0.834	0.901	0.753
	INT2	0.932			
	INT3	0.764			
Subjective Norms (SN)	SN1	0.873	0.869	0.910	0.717
	SN2	0.858			
	SN3	0.814			
	SN4	0.840			
Perceived Behavioural Control (PBC)	PBC1	0.783	0.814	0.890	0.731
	PBC2	0.892			
	PBC3	0.885			
Attitude toward BCT (ATT)	ATT1	0.882	0.893	0.926	0.757
	ATT2	0.841			
	ATT3	0.900			

	ATT4	0.856			
Trust toward Quality Certifications (TQC)	TQC1	0.908	0.904	0.940	0.839
	TQC2	0.929			
	TQC3	0.911			
Attitudes toward Technology (TEC)	TEC1	0.916	0.916	0.947	0.856
	TEC2	0.929			
	TEC3	0.930			

Discriminant validity shows the extent to which the items represent the target construct and whether a latent variable measures a separate construct (Russo & Stol, 2021). In this study discriminant validity assessed with the Heterotrait-monotrait ratio of the correlations (HTMT). The Heterotrait-Monotrait ratio of correlations (HTMT) is defined as the average of the correlations between items measuring different constructs (heterotrait correlations) relative to the geometric mean of the average correlations for items measuring the same construct (monotrait correlations) (Hair et al., 2019). The result of Table 5 illustrates that all Heterotrait-monotrait ratio of correlations (HTMT) are below the threshold value of 0.90recommended by (Hair et al., 2019), which confirms the sufficient discriminant validity of the individual constructs. It can therefore be concluded that the measurement model fulfils the required criteria for validity and reliability (reliability as well as convergent and discriminant validity).

Table 5. Results of the discriminant validity - Heterotrait-monotrait ratio of correlations (HTMT)	INT	SN	PBC	ATT	TQC	TEC
INT						
SN	0.782					
PBC	0.762	0.680				

ATT	0.690	0.695	0.856			
TQC	0.404	0.494	0.487	0.389		
TEC	0.730	0.563	0.798	0.772	0.270	

We evaluate the structural model in terms of variance explained (R2), effect size (f2), predictive relevance (Q2), path coefficient (β), and hypotheses testing. The structural model is employed for the purpose of investigating the impact of exogenous variables on endogenous variables. The results of the hypotheses developed are shown in Table 6. The adjusted R2 of 0.58 indicates that subjective norms, perceived behavioural control, and attitudes toward technology explain a substantial portion of the variance in consumers' intentions to purchase traced pasta using blockchain technology.

Effect size (f2) was calculated to measure the magnitude of the significant effects. As Cohen (1988) suggested, in the structural model, f2 values of 0.02 indicate small effects. 0.15 indicates medium effects, and 0.35 indicates large effects (Bani-Khalid et al., 2022). Table 5 shows that Subjective Norms have a medium effect size, and Perceived Behavioural Control and Attitude toward Technology have a small effect size.

In this step, the Q2 value is calculated to evaluate the PLS path model's predictive accuracy. The approach relies on the blindfolding technique that eliminates individual points from the data matrix. These omitted points are then imputed using the mean, followed by estimating the model parameters. Thus, the Q^2 does not exclusively represent out-of-sample prediction; it reflects a combination of out-of-sample predictive ability and in-sample explanatory power. The blindfold procedure predicts the missing data points for each variable using these estimated parameters as inputs. Small discrepancies between the original and predicted values result in a higher Q2 value, indicating higher prediction accuracy (Hair et al., 2019). Based on the result of Table 6, the Q2 value for the endogenous latent construct is greater than zero.

The conclusions were drawn based on p-values (see Table 6), which led to the decision to accept or reject the hypotheses taken in the study.

To answer H1: "Subjective norms positively affects the intention to purchase pasta traced with blockchain technology", the results show that SN have a statistically significant positive effect on the INT to purchase blockchain-traceable products. Therefore, the H1 is accepted. The coefficient of 0.403 indicates that social influence plays a significant role in shaping consumer behaviour.

To answer hypothesis H2 "perceived behavioural control positively affects the intention to purchase pasta traced with blockchain technology", it was also found to have a positive and significant effect on intention. However, the effect size (0.032) was smaller than that of SN. Thus, H2 is accepted.

In response to H3 "Attitude towards traceability positively affects the intention to purchase pasta traced with blockchain technology", contrary to expectations, ATT did not significantly affect intention. The very low coefficient and the high p-value (0.969) indicate that the attitude towards blockchain-traceable products does not directly influence the purchase intention in this context. Therefore, H3 is rejected.

Hypothesis H4, "Trust in quality certifications positively affects the intention to purchase pasta traced with blockchain technology", was not supported, as indicated by the non-significant coefficient (0.006) and high p-value (0.913).

To answer H5 "Attitude towards technology positively affects the intention to purchase pasta traced with blockchain technology", TEC has a significant and positive influence on purchase intention with a coefficient of 0.306. Therefore, the H5 is accepted.

Table 6 Result of the hypothesis testing

Hypothesis No.	**Relationship**	**Coefficient**	***p*-Value**	**Decision**	R^2_a	Q^2	F^2
H1	SN -> INT	0.403	0.000***	confirmed	0.582	0.439	0.216
H2	PBC -> INT	0.187	0.017**	confirmed			0.032
H3	ATT-> INT	0.003	0.969	unconfirmed			0.000
H4	TQC -> INT	0.006	0.913	unconfirmed			0.000
H5	TEC -> INT	0.306	0.000***	confirmed			0.099

Note: ** $p < 0.05$, *** $p < 0.01$

5. Discussion

This study provides empirical evidence on the determinants influencing consumers' intention to purchase blockchain-enriched products, with a focus on pasta. The results highlight important factors influencing consumer behaviour and offer practical implications for marketers and policy makers seeking to promote the adoption of blockchain technology in the food industry. These include subjective norms, perceived behavioral control, and attitudes toward technology, which significantly influenced consumers' purchase intentions for blockchain-traceable organic pasta. The results confirm that technology readiness is an important determinant of consumers' willingness to purchase pasta with blockchain-based traceability. Result indicates that consumers who have a positive attitude towards technological innovation are more likely to have the intention to purchase blockchain-traceable products. This is consistent with the Technology Readiness Index (TRI), which postulates that optimism and familiarity with technology can facilitate the adoption of new technological solutions (Parasuraman, 2000). The significance of this relationship suggests that fostering a positive attitude towards the benefits of technology, such as increased transparency and safety in the food supply chain, may encourage consumers to adopt products that utilise blockchain traceability. This emphasises the importance of education and technological awareness in marketing strategies. This result is consistent with the findings of Lin et al. (2021), who also found a positive correlation between consumers' technology readiness and their willingness to purchase technology-enabled products. The positive impact of TEC suggests that individuals with an optimistic attitude towards the benefits and simplicity of technological products are more willing to accept products that incorporate blockchain for traceability. This finding emphasises the importance of technological awareness and educational initiatives. Concrete examples of educational initiatives include awareness campaigns to educate the public on how blockchain improves food traceability and safety; interactive digital tools, such as mobile apps or QR codes on packaging, that allow consumers to access transparent supply chain data; and workshops and online courses aimed at consumers and food professionals to improve understanding and trust in blockchain-based certifications.

This result provides a valuable opportunity for companies to develop marketing campaigns that emphasise the transparency, security and innovation of blockchain technology. In this way, companies can gain consumer trust and encourage adoption. For example, educating consumers about how blockchain technology guarantees authenticity and traceability could appeal to technologically people who value innovation and transparency in their food.

The study found that ATT does not have a significant impact on purchase intent. This result may be explained by the specificity of blockchain technology, where consumers may not fully understand or prioritise the benefits even if they have a positive attitude towards it. Alternatively, external factors such as lack of trust could also have a stronger influence on purchasing decisions, thus obscuring the effect of attitude. This result is in line with the findings of previous studies by Dang & Tran (2020) and Prisco et al. (2022), which found that general attitudes towards a product do not always translate into purchase behaviour, especially in contexts where consumers do not fully understand or appreciate the perceived benefits. However, this finding contradicts the results of Dionysis et al. (2022), who postulated that a positive attitude towards traceability and transparency in the food industry is a good predictor of purchase intention. The divergence in results may be attributed to contextual differences or the presence of features of blockchain technology that consumers have not yet fully understood. Even if consumers are in favour of the concept of traceability, this does not necessarily mean that they are motivated to buy pasta with blockchain traceability. This suggests a disconnect between attitudes and actions, with consumer attitudes not always translating into actual purchasing behaviour. Further research could explore how this gap can be bridged by linking blockchain traceability to more directly perceived benefits such as food safety, quality assurance and environmental sustainability.

PBC was identified as an important predictor of purchase intention, suggesting that consumers who believe they have the ability and resources to identify and utilise blockchain-traceable pasta products are significantly more likely to express a purchase intention. This result is consistent with the TPB framework, which states that consumers who feel able to find and use blockchain traceable products are more likely to have the intention to purchase them. This finding emphasises the importance of

ease of access and use for technology-driven innovations such as blockchain. Improving the level of control perceived by consumers through intuitive applications and clearer information can increase the likelihood of adoption. Moreover, the finding is consistent with the results of studies by Lin et al. (2021), Dang & Tran (2020), Dionysis et al. (2022) and Prisco et al. (2022), which have shown that PBC plays a central role in influencing consumer intentions, especially in the context of new technology adoption. The significant role of PBC suggests that ease of access and use are key factors for consumers. If consumers perceive blockchain-traceable pasta as easily accessible and verifiable, they are more likely to express interest in purchasing it. Therefore, companies should prioritise the development of user-friendly and accessible blockchain-based traceability solutions. One possible solution is the development of straightforward applications or digital resources that allow consumers to effortlessly verify the traceability of products, improving their perceived control over the purchasing process. Despite the inconsistency of SN as a predictor in different studies, the results of this research context show its importance. This result is consistent with the theory of planned behaviour, which postulates that the approval and support of significant others, e.g. family, friends and social networks, can strongly influence a person's behavioural intentions (Ajzen, 1991).

This suggests that opinions, recommendations and social pressure from peers, family, media and credible authorities are critical to consumers' intention to purchase pasta with blockchain traceability. This finding contradicts the discrepancies observed in other studies, but highlights an important aspect of social influence on consumer behaviour. The importance of subjective norms in this study suggests that social acceptance and approval can be effective in driving the adoption of products with blockchain traceability. Incorporating social evidence, such as endorsements from influencers, experts, and food industry leaders, into marketing strategies could effectively generate consumer interest. In addition, the implementation of educational initiatives that spread knowledge about the benefits of blockchain technology, supported by authoritative figures such as scientists and food safety professionals, could help to reinforce societal expectations of purchasing such products.

Finally, the hypothesis that trust in quality certifications directly influences consumers' intention to buy products with blockchain traceability was not confirmed. This result indicates that trust in existing quality certifications does not necessarily lead to a higher purchase intention for blockchain-traceable products. One possible explanation for this is that while consumers trust conventional quality certifications, they do not perceive traceability via blockchain as directly linked to these traditional certifications or do not see it as an added value. The lack of significant results could also be due to a knowledge gap or a lack of perceived relevance between quality certifications and blockchain technology. This result is in line with the result reported by Contini et al. (2023). They also found that trust in traditional quality certifications is not necessarily transferable to new technological applications. This can be attributed to the fact that there is no recognisable link in consumers' minds between blockchain traceability and existing quality measures. The lack of emphasis on the role of trust suggests that consumers may not perceive blockchain technology as a natural extension of existing quality certification systems. An alternative explanation is that respondents may have a high level of trust in traditional certifications, but do not perceive the value of blockchain technology as being enhanced by them. This emphasises the need for clear communication about how blockchain can complement and enhance quality certification by providing additional layers of transparency and authenticity beyond traditional systems.

6. Conclusion

This study provides new insights into the factors that influence consumers' intention to buy blockchain-labelled pasta. The study highlights that while attitudes towards the technology positively influence consumer purchase intentions, general attitudes towards products with blockchain traceability and trust in existing quality certifications were not found to be significant predictors. This suggests that successful marketing strategies should focus on educating consumers about the benefits of blockchain, simplifying the user experience, and leveraging social influences to drive adoption of blockchain-based traceability.

These findings have important implications for both policy makers and producers in the agri-food sector. For policy makers, the study suggests that blockchain technology can be an important tool to combat food fraud and ensure food safety and quality. There is therefore a need for supportive policies and regulations that promote the adoption and implementation of blockchain throughout the food supply chain. Governments can incentivize blockchain adoption to improve trust in food certifications through targeted policies and financial support. First, governments could launch consumer education initiatives, such as awareness campaigns and digital tools, to improve public understanding of how blockchain enhances food safety and authenticity. Finally, regulators could develop clear and enforceable standards for blockchain traceability, ensuring that certified products meet high standards of transparency and accountability.

For producers, the results of this study can help develop effective marketing and communication strategies to promote products with blockchain traceability. By emphasising benefits such as authenticity, traceability and sustainability, producers can gain consumer trust and increase the appeal of products with blockchain traceability.

While blockchain can potentially increase trust in existing quality signals, the challenge is to effectively communicate its benefits to consumers. By recognising the importance of social norms, attitudes towards technology and perceived behavioural control, stakeholders can promote transparency, accountability and sustainability in the agri-food industry, creating a more efficient and competitive environment.

Although we acknowledge the limitation of our sample size, the use of PLS-SEM ensures the robustness of our results, as this method is suitable for studies with relatively small samples (Hair et al., 2011; Sarstedt et al., 2016). This method allows us to work with small sample sizes, maximize explained variance, and minimize estimation bias (Russo & Stol, 2002). Moreover, the combination of snowball and random sampling is effective for data collection, it is important to recognise the inherent limitations of these techniques. First and foremost, there is the possibility of selection bias

in non-probability sampling. For future studies, it would be beneficial to consider the use of random sampling to minimise bias.

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