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Consumer Acceptance of Enabling Agri-Food Technologies for Sustainable Food Systems: Evidence From Italy

Giulio Cascone | Giuseppe Timpanaro

Department of Agriculture, Food and Environment, University of Catania, Catania, Italy

Correspondence: Giulio Cascone (giulio.cascone@phd.unict.it)

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ABSTRACT

The transition toward more sustainable and innovative agricultural systems increasingly relies on the integration of digital and enabling technologies (KETs). Although the technical and productive aspects of these innovations have been widely investigated, consumer acceptance remains less understood, despite its key role in fostering their adoption. This study explores the psychological, cognitive, and social factors that influence consumers' purchase intentions regarding products derived from enabling technologies in agriculture. A large-scale survey was conducted with 2127 Italian consumers, using validated scales to measure environmental concern, food technology neophobia, subjective social norms, and subjective knowledge. Partial least squares structural equation modeling (PLS-SEM) was applied to test the hypothesized relationships. The results show that subjective social norms and perceived knowledge are the strongest predictors of purchase intention, whereas environmental concern exerts a positive but weaker effect. In contrast, food technology neophobia emerges as a significant barrier to acceptance. These findings highlight the central role of social dynamics and consumer literacy in fostering the acceptance of agri-food innovations. The study contributes to the literature by introducing subjective knowledge as a key determinant and addressing a gap in consumer perceptions of enabling technologies. Practical implications are discussed for policymakers, marketers, and agri-food stakeholders aiming to design effective communication strategies, enhance transparency, and build trust in the sustainable digital transition of agriculture.

1 | Introduction

Agriculture today faces major environmental and social challenges, as intensive practices have accelerated biodiversity loss and ecosystem degradation, whereas the heavy use of pesticides and fertilizers has compromised the quality of water, air, and soil (Gamage et al. 2023; Gržinić et al. 2023; De Corato 2020). To address these issues, the adoption of digital technologies is crucial, as they can facilitate the transition toward more environmentally sustainable agricultural systems. Such technologies help reduce the use of productive inputs, lower production costs, and mitigate ecological impacts (Da Silveira et al. 2021). The digital transformation of agriculture offers opportunities to alleviate environmental pressures, preserve resources, and stimulate innovation-led rural development (Lioutas et al. 2021; Abbasi et al. 2022).

Enabling technologies (KETs) have become central to this transformation, introducing new paradigms in farm management and decision-making (Finger 2023; MacPherson et al. 2022). Precision farming, the Internet of Things (IoT), artificial intelligence, and automation are reshaping

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This study explores consumer acceptance of enabling technologies applied in agriculture, analyzing the psychological, social, and cognitive factors that influence purchase intentions for food products derived from these innovations. The research provides insights into the role of perceived knowledge, social norms, and technology-related neophobia in supporting a sustainable digital transition in the agri-food sector.

agricultural production through data-driven and adaptive systems. For instance, IoT sensors and satellite imagery enable continuous monitoring of crops and soils, whereas AI tools assist in forecasting yields or detecting diseases (Vasileiou et al. 2024; Timpanaro et al. 2025). Robotics, drones, and automated machinery are streamlining field operations, and blockchain is enhancing traceability and transparency across supply chains (Dey and Shekhawat 2021). Collectively, these technologies contribute to greater sustainability, efficiency, and competitiveness.

Despite the transformative potential of emerging technologies in agriculture and the food industry, the adoption of digital 4.0 solutions remains limited, particularly among small producers. This lag is especially evident when comparing adoption rates between developed and developing countries (Y Sun et al. 2024; Granado-Díaz et al. 2024). Several studies identify barriers that hinder KET diffusion in agriculture, ranging from high initial costs and skill gaps to infrastructure limitations and regulatory constraints. (Timpanaro et al. 2024). Additional barriers include concerns about data security and privacy, issues of technological complexity and incompatibility with existing farm management systems, and cultural resistance to change and regulatory or political constraints (Bissadu et al. 2024; Fragomeli et al. 2024).

Such constraints delay the shift toward innovative and sustainable agricultural practices. To overcome them, it is essential to identify motivational drivers that can encourage producers to adopt such solutions. One of the most relevant forces may come from consumer demand, as purchasing preferences and behaviors can directly influence farmers' decisions. The literature has highlighted the importance of factors such as attitudes toward sustainability, access to clear information, and sensitivity to environmental issues (Liu et al. 2021; Hassoun et al. 2022). However, knowledge (KN) about the psychological and social mechanisms shaping consumption intentions remains limited. In particular, the role of subjective KN of technologies and trust in the institutions and companies implementing them is still underexplored, as is consumer perception of specific technologies (e.g., robotics vs. blockchain), which has rarely been analyzed in a differentiated way.

Therefore, understanding what drives consumers to prefer products obtained through the adoption of enabling technologies in agriculture is crucial to supporting a sustainable transition (Rehman et al. 2023; Fan et al. 2024). Consumer engagement is increasingly recognized as a key driver of agricultural innovation and sustainability (Liu et al. 2021; Riva et al. 2022). Factors such as access to clear information and a favorable attitude toward sustainable consumption are key to encouraging the acceptance of products derived from advanced technologies (Yang and Hobbs 2020; Oliveira et al., 2021). The limited consumer awareness of the benefits of "smart" agriculture (Azlan et al. 2023) underscores the need to investigate the psychological and social mechanisms that influence consumption choices related to products obtained through KETs.

This study aims to analyze the psychological, cognitive, and social factors that shape consumers' intentions to purchase agricultural products obtained using KETs. In particular, the analysis focuses on the influence of environmental concern, food technology neophobia (FTN), subjective social norms, and the level of subjective KN of the technologies employed. The relevance of this research lies in its contribution to the broader debate on the digital transition of agriculture, highlighting the crucial role of consumers as actors capable of influencing the adoption and diffusion of innovations. Although the technical and productive aspects of KETs have been widely examined, empirical evidence on consumer perceptions and the psychological and social mechanisms guiding their purchasing decisions remains limited. This research provides two main contributions: First, it offers new evidence on how consumers perceive the use of innovative technologies in agriculture and on the factors driving their acceptance; second, it explores a gap in the literature by focusing on underexplored variables, such as subjective KN and its role in shaping consumption intentions.

Beyond individual consumption choices, consumer acceptance of enabling technologies has important strategic implications for firms operating in the agri-food sector. Market acceptance of technologically enabled products can reduce perceived demand uncertainty, support investment decisions, and facilitate the alignment of business strategies with sustainability goals. In this sense, understanding the drivers of consumer acceptance is relevant not only from a behavioral perspective but also for identifying the conditions under which enabling technologies can effectively contribute to environmental value creation and sustainability transitions in agri-food systems.

2 | Conceptual Model and Research Hypotheses

A key determinant is environmental concern, reflecting individuals' sensitivity to ecological challenges and sustainability awareness. However, consumer acceptance of such innovations is not guaranteed and depends on a combination of psychological, social, and cognitive factors that influence consumption intentions.

One of the main factors is environmental concern, which reflects individuals' awareness and sensitivity toward ecological issues. The literature shows that consumers with greater attention to environmental matters tend to display a more favorable attitude toward innovations that contribute to reducing the impact of traditional farming practices, such as enabling technologies (Bocean 2024; Timpanaro and Cascone 2025). Empirical evidence indicates that environmental concern plays an important role in shaping attitudes toward technological innovations in food production. (Giacalone and Jaeger 2023; Califano et al. 2024). Therefore, the following hypothesis is proposed:

Hypothesis 1. *Environmental concern positively influences the intention to consume foods produced through enabling technologies.*

FTN captures consumers' reluctance or distrust toward foods produced with novel technological processes. The literature indicates that high levels of FTN can reduce consumers' openness toward products perceived as "distant" from traditional methods, thereby slowing their adoption (Cox and Evans 2008;

Vidigal et al. 2015). A recent systematic review confirmed that FTN is a robust predictor of negative consumer reactions to innovative foods (Wendt and Weinrich 2023). Consequently, the following hypothesis is proposed:

Hypothesis 2. *FTN negatively affects the intention to consume foods produced through enabling technologies.*

According to the Theory of Planned Behavior, subjective norms (SN) express the perceived social expectations that influence individual decision-making (Ajzen 2002; Sok et al. 2021). In contexts characterized by high technological uncertainty, consumers tend to rely more heavily on the opinions of friends, family members, and reference groups (Siddiqui et al. 2022; Siegrist 2008). Accordingly, the following hypothesis is proposed:

Hypothesis 3. *SN positively influences the intention to consume foods produced through enabling technologies.*

Recent studies emphasize that consumers' perceived KN—how well they believe they understand a technology and its benefits—significantly influences acceptance of innovation (Parrella et al. 2023). A higher perceived KN reduces uncertainty and fosters more informed purchasing decisions, thereby increasing openness to innovations (Bearth and Siegrist 2016; Pfeiffer et al. 2021). In line with this evidence, the following hypothesis is proposed:

Hypothesis 4. *A higher level of KN of enabling technologies increases the intention to consume foods produced through such technologies.*

Finally, several studies have shown that sociodemographic variables can significantly influence consumer behavior toward food innovations (Hellali and Korai 2023; Boogaard et al. 2011). Sociodemographic factors such as gender, age, education, and income are expected to influence consumers' preferences and purchase intentions for technologically produced foods. Therefore, the following hypothesis is proposed:

Hypothesis 5. *Sociodemographic variables (gender, age, education level, and income) significantly influence the intention to consume foods produced through enabling technologies.*

3 | Materials and Methods

3.1 | Data Collection

From December 2024 to April 2025, data were collected through an online CAWI survey conducted by a professional research agency. A total of 2127 complete questionnaires were collected. The survey was administered through the agency's digital platform and distributed via email to participants selected through an automated distribution system. Eligibility criteria required respondents to be adults aged 18 years or older and responsible for their household food purchases. Although the sample is not intended to be statistically representative of the Italian population, demographic stratification was employed to improve diversity and ensure adequate coverage of major sociodemographic groups.

All procedures complied with recognized ethical guidelines, including the principles of the Declaration of Helsinki. No sensitive data (e.g., political or sexual orientation) were collected. All responses were recorded anonymously and stored securely. The research protocol was approved by the Bioethics Committee of the University of Catania, and participants provided informed consent before completing the questionnaire.

3.2 | Questionnaire Preparation

The questionnaire was divided into two main sections. Initially, respondents received a concise and neutral overview of enabling technologies in agriculture, outlining their main applications. These descriptions were drafted by a member of the research team with expertise in the field, with the aim of offering a neutral and general overview of the methodologies, while avoiding any specific framing or interpretative bias. The descriptions were subsequently revised and refined by the rest of the team to ensure clarity, consistency, and neutrality.

The first section included scales designed to measure the psychological, social, and cognitive constructs analyzed in the study (Table 1):

- FTN was measured through 13 items adapted from Cox and Evans (2008), rated on a 5-point Likert scale from “strongly disagree” to “strongly agree.” Higher scores indicate greater neophobia.
- Environmental concern was assessed using the revised NEP scale (Dunlap et al. 2000), composed of eight 5-point Likert items. Higher values correspond to stronger proenvironmental orientation.
- Perceived social influence (SNN) was assessed through three ad hoc items designed to capture the degree of social pressure that respondents feel from people important to them—such as relatives, friends, or peers—regarding the purchase of foods produced with enabling technologies. Higher values reflect stronger perceived endorsement from one's social environment.
- Participants' perceived KN of enabling technologies was measured using five items adapted from Parrella et al. (2024). The scale captures individuals' self-assessed familiarity with the principles, applications, and potential benefits of KETs in agriculture. Greater scores indicate higher informational awareness and confidence in evaluating such innovations.
- Behavioral intention (INT) toward the consumption of products obtained through enabling technologies was evaluated through three items reflecting respondents' willingness and plans to include these products in their diet. Higher scores correspond to a stronger intention to purchase or consume foods derived from KET-based agricultural practices.

In the second section, participants were asked to provide information about their sociodemographic characteristics. These data were used to describe the profile of the sample (Table 2) and to analyze the effect of sociodemographic variables on consumption intentions.

TABLE 1 | Items used with main statistics.

Item	Statement	Mean	SD
INT_1	I intend to consume agricultural products obtained using innovative technologies in the future.	3.25	1.05
INT_2	I feel a strong desire to include agricultural products obtained through advanced technologies in my diet soon.	2.90	1.11
INT_3	In the future, I plan to consume agricultural products derived from enabling technologies more frequently.	3.02	1.07
FTN_1	There is no need to use advanced technologies in agriculture because traditional methods are already sufficient to produce quality food.	2.38	1.18
FTN_2	I feel uncertain about the use of innovative technologies in agriculture.	2.55	1.17
FTN_3	Foods produced with innovative agricultural technologies are not healthier than those obtained using traditional methods.	2.88	1.14
FTN_4	The benefits of innovative technologies in agriculture are often exaggerated.	2.80	1.10
FTN_5	There is already enough good food, so there is no need to introduce new technologies to produce more.	2.56	1.22
FTN_6	The use of innovative technologies in agriculture reduces the natural quality of food.	2.70	1.20
FTN_7	It is unlikely that innovative agricultural technologies will have long-term negative effects on health.[a]	3.10	1.09
FTN_8	Innovative agricultural technologies can give consumers greater control over their food choices.[a]	3.33	0.98
FTN_9	Products made with the help of advanced agricultural technologies can help people follow a more sustainable and balanced diet.[a]	3.22	1.06
FTN_{10}	Innovative agricultural technologies could have long-term negative effects on the environment.	2.94	1.06
FTN_{11}	It is risky to adopt innovative agricultural technologies too quickly	3.08	1.11
FTN_{12}	Society should not rely too heavily on technologies to solve problems related to food production.	2.82	1.16
FTN_{13}	The media usually provide a balanced and impartial view of innovative agricultural technologies.[a]	2.70	1.07
NEP_1	We are approaching the limit of the planet's ability to support the human population.	3.78	1.10
NEP_2	When humans interfere with natural processes, disastrous consequences often occur.	3.86	1.00
NEP_3	Human activities are severely damaging the environment.	4.07	0.98
NEP_4	Plants and animals have the same right to exist as humans.	4.16	0.99
NEP_5	Despite our abilities, humans are still subject to the laws of nature.	4.22	0.91
NEP_6	The Earth is like a spaceship with very limited resources and space.	3.90	1.04
NEP_7	The balance of nature is extremely delicate and can easily be disrupted.	4.13	0.95
NEP_8	If we continue our current course, we will soon face a serious ecological catastrophe.	4.04	1.04
SN_1	People I consider important would approve of my decision to purchase agricultural products obtained through innovative technologies.	3.31	0.99
SN_2	The people who are important to me believe I should support farmers who adopt enabling technologies.	3.16	0.97
SN_3	Many people I know would be willing to consume agricultural products derived from advanced and sustainable technologies.	3.30	1.02

(Continues)

TABLE 1 | (Continued)

Item	Statement	Mean	SD
KN_1	I feel well-informed about the innovative technologies used in agriculture.	2.53	1.06
KN_2	I believe I have a good understanding of the benefits of digital technologies applied to agriculture.	2.59	1.08
KN_3	I can distinguish between a product obtained using traditional agricultural methods and one produced with innovative technologies.	2.54	1.16
KN_4	I have read or heard about agricultural practices based on digital technologies, such as precision farming.	2.71	1.17
KN_5	I feel confident in assessing the quality of a product obtained using advanced agricultural technologies.	2.66	1.12

Abbreviations: FTN = food technology neophobia scale; INT = intention; KN = subjective knowledge; NEP = new ecological paradigm; SN = subjective norms.
[a]Item reverse scored.

3.3 | Data Analysis

We used the partial least squares structural equation modeling (PLS-SEM) approach to evaluate the hypothesized relationships among constructs. The hypothesized theoretical model (Figure 1) links environmental concern, FTN, SN, subjective KN, and sociodemographic variables with the intention to consume foods produced through enabling technologies. Sociodemographic characteristics were included as control variables to account for potential heterogeneity in consumers' behavioral intentions. Gender was coded as a binary variable (0 = female, 1 = male), whereas age, education level, and income were modeled as ordinal variables reflecting increasing categories. These variables were incorporated into the structural model as single-item observed predictors of behavioral intention, and their effects are interpreted as controls rather than primary theoretical relationships. PLS-SEM, like conventional SEM, includes a measurement model linking constructs to their indicators and a structural model that specifies relations among constructs. (Venturini and Mehmetoglu 2019; Cammarata et al. 2024). PLS-SEM was selected due to its strong prediction-oriented approach and its suitability for estimating complex models with multiple latent constructs (Hair et al. 2019; Gallagher et al. 2022). The primary objective of this study is to explain and predict consumers' behavioral intentions toward products derived from enabling technologies, making PLS-SEM particularly appropriate. Additionally, this method provides robust parameter estimates without requiring strict distributional assumptions. Negatively worded items were reverse-coded prior to the analysis to ensure conceptual alignment with the direction of the construct. To examine the potential common method bias, the full collinearity VIF approach proposed by Kock and Lynn (2012) was followed. For each latent construct, a regression was estimated in which the target variable was predicted by all other constructs and sociodemographic controls (age, gender, education, income). All VIF values are significantly below the critical threshold of 3.3 (Table A1), suggesting that common method bias does not pose a significant threat to the validity of the estimates.

After defining the measurement model, specific criteria were applied to assess its reliability and validity. Reliability was assessed by factor loadings (> 0.50), Cronbach's α, and rho_A (> 0.70). Convergent validity was evaluated using the average variance extracted (AVE), with a minimum threshold of 0.50. Discriminant validity was checked using the Fornell–Larcker criterion, ensuring that each construct's AVE square root exceeded its correlations with other constructs (Capasso et al. 2023). It was additionally evaluated using the heterotrait–monotrait ratio of correlations (HTMT), which is considered a more reliable criterion than traditional approaches such as the Fornell–Larcker criterion. Following established guidelines, HTMT values below the conservative threshold of 0.85 were deemed indicative of adequate discriminant validity among the latent constructs (Rasoolimanesh 2022). The structural model was evaluated by examining path coefficients, their statistical significance, and the model's explanatory and predictive capabilities (Lombardi et al. 2024). The significance of path coefficients was assessed using bootstrapping with 5000 resamples, generating bias-corrected confidence intervals.

4 | Results

This section presents the assessment of the measurement model, followed by the evaluation of the structural relationships among the constructs. The analyses were conducted using Stata version 19.

To evaluate the measurement model, we tested reliability and both convergent and discriminant validity across all constructs. Table 3 reports the standardized factor loadings, Cronbach's α, rho_A, and AVE for each construct. Most indicators exhibited loadings exceeding the 0.50 cut-off, confirming acceptable reliability. FTN7 and FTN13 were reverse-worded items and were therefore reverse-coded prior to model estimation to ensure directional consistency with the remaining indicators. After rechecking the coding procedure, both items continued to display weak outer loadings and limited indicator reliability. Reverse-worded statements are known to increase respondents' cognitive burden and may generate misunderstanding in self-administered online surveys, thereby introducing measurement error. For this reason, and in line with PLS-SEM guidelines, the two indicators were removed, resulting in improved internal consistency and convergent validity of the FTN construct. Reliability was adequate across constructs, with Cronbach's α

TABLE 2 | Sample characteristics ($N = 2127$).

Variable	Variable description	Absolute frequency	Percentage frequency (%)
Gender	Male	1075	50.54
	Female	1051	49.41
	Other/prefer not to answer	1	0.05
Age	18–29 years	387	18.19
	30–44 years	549	25.81
	45–54 years	488	22.94
	55–70 years	703	33.05
Area	North Italy	988	46.45
	Middle Italy	420	19.75
	South and Islands	719	33.8
Education	None	1	0.05
	Elementary school	8	0.38
	Middle school	245	11.52
	High school	1086	51.06
	Bachelor degree	287	13.49
	Master's degree	435	20.45
	PhD	65	3.06
Current occupation	Unemployed	309	14.53
	Student	175	8.23
	Self-employed	239	11.24
	Employee	1163	54.68
	Retired	241	11.33
Monthly income	< 2000 €	1495	70.29
	2000–4000 €	548	25.76
	> 4000€	84	3.95

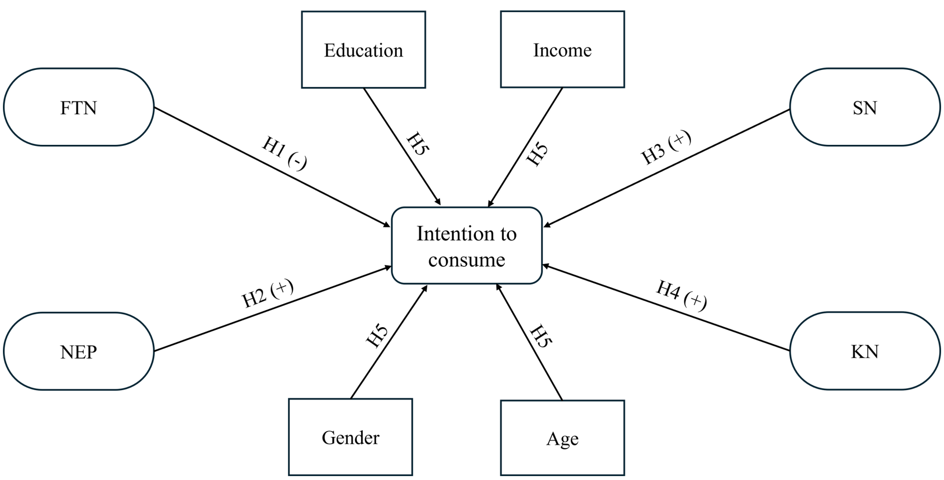

FIGURE 1 | Hypothesized model. Plus and minus signs indicate the direction of the hypothesized relation, as coded in parentheses. FTN = food technology neophobia scale; KN = subjective knowledge; NEP = new ecological paradigm; SN = subjective norms.

TABLE 3 | Measurement model of the PLS-SEM.

Item/construct	FTN	NEP	SN	KN	INT
FTN_1	0.704				
FTN_2	0.699				
FTN_3	0.628				
FTN_4	0.742				
FTN_5	0.783				
FTN_6	0.786				
FTN_8	0.549				
FTN_9	0.536				
FTN_{10}	0.700				
FTN_{11}	0.710				
FTN_{12}	0.751				
NEP_1		0.802			
NEP_2		0.487			
NEP_3		0.767			
NEP_4		0.564			
NEP_5		0.588			
NEP_6		0.812			
NEP_7		0.808			
NEP_8		0.858			
SN_1			0.875		
SN_2			0.848		
SN_3			0.854		
KN_1				0.893	
KN_2				0.895	
KN_3				0.765	
KN_4				0.831	
KN_5				0.843	
INT_1					0.886
INT_2					0.905
INT_3					0.916
Cronbach's α	0.856	0.896	0.822	0.902	0.886
rho_A	0.890	0.897	0.894	0.927	0.929
AVE	0.512	0.523	0.738	0.717	0.815

Abbreviations: FTN = food technology neophobia scale; INT = intention; KN = subjective knowledge; NEP = new ecological paradigm; SN = subjective norms.

values (0.822–0.902) comfortably exceeding the 0.70 threshold. Similarly, rho_A values ranged between 0.890 and 0.929, confirming the robustness of the measurement model. Regarding convergent validity, all constructs reported AVE values above the suggested threshold of 0.50, ranging from 0.512 (FTN) to 0.815 (INT). This indicates that the indicators adequately capture the variance of their respective constructs. We confirmed discriminant validity via the Fornell–Larcker criterion: Each construct's AVE square root exceeded its inter-construct correlations, as shown in Table 4. The HTMT results (Table 5) confirmed satisfactory discriminant validity, as all values were below the conservative threshold of 0.85. The highest ratio was observed between SN and intention (HTMT = 0.812), remaining within acceptable limits and indicating that the constructs are empirically distinct. This result confirms that each construct shares more variance with its own indicators than with any other construct in the model, thus meeting the requirement of discriminant validity.

TABLE 4 | Discriminant validity with the Fornell–Larcker criterion.

	FTN	NEP	SN	KN	INT
FTN	0.716				
NEP	0.024	0.723			
SN	0.250	0.600	0.859		
KN	0.001	0.005	0.130	0.847	
INT	0.321	0.034	0.482	0.194	0.903

Note: Diagonal elements represent the square root of the average variance extracted (AVE). Discriminant validity is established when each construct shares more variance with its indicators than with other constructs. Abbreviations: FTN = food technology neophobia scale; INT = intention; KN = subjective knowledge; NEP = new ecological paradigm; SN = subjective norms.

TABLE 5 | Discriminant validity assessment using the heterotrait–monotrait ratio (HTMT).

	FTN	NEP	SN	KN
FTN				
NEP	0.057			
SN	0.586	0.209		
KN	0.014	0.118	0.402	
INT	0.641	0.108	0.812	0.475

Note: All HTMT values are below the conservative threshold of 0.85, supporting discriminant validity.

The structural model results are presented in Table 6 and Figure 2. Overall, the model exhibits strong explanatory power, accounting for 61.8% of the variance in behavioral intention ($R^2 = 0.618$). Furthermore, the Stone–Geisser Q^2 value of 0.486 indicates high predictive relevance. Environmental concern (NEP) exerts a positive effect ($\beta = 0.057$, $p < 0.001$); however, its practical relevance appears negligible given the very small effect size ($f^2 = 0.007$), despite supporting Hypothesis 1. FTN shows a negative and statistically significant effect on intention ($\beta = -0.345$, $p < 0.001$), with a medium effect size ($f^2 = 0.224$), thereby confirming Hypothesis 2. SN emerge as the strongest predictor of intention ($\beta = 0.399$, $p < 0.001$), displaying the largest effect size ($f^2 = 0.248$). KN also positively influences behavioral intention ($\beta = 0.274$, $p < 0.001$) with a medium effect ($f^2 = 0.154$), supporting Hypotheses 3 and 4, respectively. Regarding

TABLE 6 | Structural model results and predictive assessment.

Path	β	Std. error	p	95% CI	f^2	Result
NEP → INT	0.057	0.014	< 0.001	[0.026; 0.082]	0.007	Supported
FTN → INT	−0.345	0.018	< 0.001	[−0.380; −0.310]	0.224	Supported
SN → INT	0.399	0.022	< 0.001	[0.358; 0.442]	0.248	Supported
KN → INT	0.274	0.017	< 0.001	[0.239; 0.307]	0.154	Supported
Gender → INT	0.024	0.014	0.093	[−0.004; 0.051]	0.001	Not supported
Age → INT	−0.032	0.014	0.024	[−0.060; −0.004]	0.002	Supported
Education → INT	0.001	0.015	0.973	[−0.029; 0.030]	0.000	Not supported
Income → INT	0.077	0.014	< 0.001	[0.050; 0.103]	0.013	Supported
Metric	Value					
R^2 (INT)	0.618					
Q^2 (INT)	0.486					

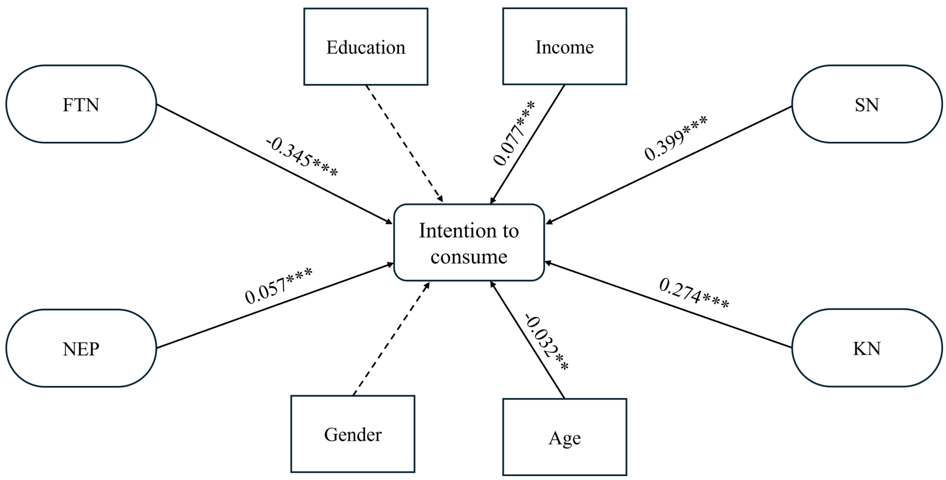

FIGURE 2 | Structural model results of PLS-SEM. The arrows in the diagram represent standardized direct effects. The dotted arrows indicate relationships that are not statistically significant ($p > 0.05$), whereas the solid arrows represent significant effects, with different levels of significance: * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

TABLE 7 | Structural model—Multicollinearity check (variance inflated factors—VIFs).

	INT
FTN	1.394
NEP	1.108
SN	1.692
KN	1.275
Gender	1.051
Age	1.097
Education	1.156
Income	1.150

Note: Values below 3.3 indicate an acceptable level of correlation among constructs.

sociodemographic variables, income ($\beta = 0.077$, $p < 0.001$) and age ($\beta = -0.032$, $p = 0.024$) show statistically significant relationships with intention, although their magnitude is negligible. Conversely, gender and educational level do not significantly influence behavioral intention. In addition, multicollinearity diagnostics were performed by calculating the variance inflation factor (VIF) for all latent constructs. As reported in Table 7, all VIF values were well below the critical limit of 3.3, indicating that collinearity did not affect the estimated parameters.

5 | Discussion

This research examined the psychological and social determinants of consumers' willingness to purchase products derived from enabling agricultural technologies, within the broader framework of agriculture's digital transition. At a time when the agri-food sector is required to respond to pressing environmental and production challenges through innovation, understanding the psychological and social mechanisms that drive the acceptance of such innovations is crucial. The findings contribute to the broader scientific debate on the technological transition of the primary sector, providing new empirical evidence on the factors that can facilitate or hinder the shift toward more sustainable and digitalized production models. The PLS-SEM analysis confirmed the validity of the proposed theoretical model, underscoring the central role of a combination of individual, social, and cognitive determinants in shaping behavioral intentions. Overall, the model demonstrates satisfactory explanatory and predictive capability, offering valuable insights into the dynamics underlying consumer acceptance of enabling technologies.

From a strategic perspective, these findings suggest that consumer readiness may act as an enabling condition for firms' sustainability-oriented innovation pathways. When consumers demonstrate greater openness toward enabling technologies and perceive stronger social legitimacy around their adoption, firms may face lower market uncertainty and greater incentives to invest in technologically advanced and environmentally sustainable production systems. In this sense, consumer acceptance should not be viewed merely as a behavioral outcome but as a strategic factor influencing the pace and feasibility of innovation adoption in the agri-food sector.

SN proved to be the most influential factor, indicating that social expectations and peer approval substantially shape consumers' intentions. In contexts marked by technological complexity or novelty, individuals tend to rely on the opinions of trusted reference groups, which become decisive for behavioral intention (Rizzo et al. 2024). This finding is consistent with previous research on the adoption of food innovations, which has shown that support from one's social reference group is often decisive in fostering the acceptance of sustainable production practices based on new technologies (Menozzi et al. 2017; Zhang et al. 2024).

The role of KN emerges as another key factor in explaining consumption intentions. Consumers who perceive themselves as well-informed about KETs and the benefits associated with their use are more inclined to purchase products derived from such innovations. This finding is consistent with the corpus of research that identifies KN as a lever to reduce uncertainty and increase the sense of control over consumption choices (Baker et al. 2022; Grimsby 2024). KN appears to act as an enabling factor that fosters trust in innovation, turning a technology initially perceived as distant or potentially risky into a tangible opportunity to improve sustainability and food quality. Promoting clear and accessible information campaigns, oriented toward the concrete benefits of digital agriculture, therefore emerges as essential to strengthen social acceptance of these products (Albertsen et al. 2020).

Alongside social and cognitive influences, emotional factors also play a significant role in shaping intentions. FTN emerges as a major psychological barrier to the acceptance of enabling technologies. The results confirm the hypothesis of a negative effect: Participants displaying more skeptical or adverse attitudes toward innovation show a lower intention to purchase products derived from such processes. This finding is consistent with the literature identifying FTN as one of the main obstacles to the diffusion of foods obtained through nonconventional methods (Wendt and Weinrich 2023). The perceived risk associated with the use of food technologies can indeed trigger defensive mechanisms, leading to resistance and disinterest in adopting innovative solutions, even when they provide clear environmental or nutritional benefits (Bucher et al. 2023; Yue et al. 2015). Addressing such attitudes requires targeted interventions not only at the informational level but also at the emotional one, through communication strategies aimed at reducing perceptions of unfamiliarity and strengthening a sense of closeness with innovation.

The effect of NEP on consumption intention is more modest yet remains statistically significant. This result suggests that stronger ecological sensitivity can facilitate consumers' openness toward agricultural products obtained through innovative technologies, particularly when these technologies are perceived as compatible with environmental protection. The positive association between environmental awareness and willingness to consume aligns with a broader body of empirical evidence that highlights the centrality of ecological values in shaping consumer attitudes toward innovation. Several studies suggest that a worldview more oriented toward the centrality of nature is associated with greater openness to innovations in the agri-food sector, including nonconventional farming practices and emerging technologies (Dangelico et al. 2024; Shen and Chen 2020). Mustapa and Kallas (2023) observed a higher propensity to accept animal products obtained through innovative feed, such as insect-based feed, among consumers with strong environmental sensitivity. Similarly, Hartmann and Siegrist (2017) found that high levels of ecological awareness are often linked to positive attitudes toward novel foods, suggesting that concern for environmental issues can help reduce skepticism toward innovations in the food domain.

Among the control variables included in the model, income and age showed significant effects on consumption intention. Among these, income emerges as a relevant factor: Consumers with higher economic resources are more inclined to accept the introduction of technological innovations in the agri-food sector. This result is consistent with previous research showing that the availability of financial resources can facilitate openness toward products perceived as new or advanced, often associated with added value in terms of sustainability or safety (Cattaneo et al. 2019; Hoek et al. 2011). Age also shows a significant influence, but in the opposite direction: Younger consumers report higher purchase intentions compared with older individuals. This pattern likely reflects younger consumers' stronger exposure to digitalization and their openness to experiment with novel food options (Onwezen et al. 2021; Vidigal et al. 2015). In a context of rapid technological transformation, age thus appears to act as a key variable in shaping consumer attitudes and behaviors. By contrast, education level and gender did not show statistically significant effects. Although the literature sometimes highlights greater openness among more educated individuals or a male tendency toward higher risk-taking in food consumption (Verbeke 2015; Wilkinson et al. 2018), these effects did not strongly emerge in our case. It is possible that, in the specific context of enabling technologies in agriculture, such variables play a less decisive role compared with other factors, such as environmental beliefs or social pressures.

The findings add to the existing literature by integrating psychological, social, and demographic dimensions into a unified framework explaining acceptance of enabling agricultural technologies. In particular, the relevance of SN and KN confirms the need to consider the role of social and cognitive dimensions in predictive models of consumption intention. Considering FTN and NEP together allows for a more comprehensive understanding of the psychological barriers and motivational drivers behind consumer acceptance.

From a practical standpoint, the results offer useful guidance for communication strategies aimed at increasing public trust and understanding of technology-based agri-food innovations. The significant influence of SN suggests the opportunity to activate mechanisms of social endorsement, for instance, through the involvement of credible and relatable figures (nutritionists, influencers, educators, or representatives of the agricultural sector) capable of conveying reassuring and motivating messages. In the presence of technologies perceived as complex or unfamiliar, the support of such actors can strengthen consumer trust and encourage the adoption of new behaviors. The centrality of KN highlights the importance of strengthening technological literacy among the population. Accessible and evidence-based information campaigns can help counteract misinformation and reduce the effect of distorted perceptions linked to technological novelty. NEP, although showing a weaker effect compared with other variables, may also represent a strategic lever. Emphasizing the potential contribution of enabling technologies to environmental sustainability can reinforce the perceived alignment between innovation and ecological values. This approach is particularly relevant in a context where consumers are increasingly sensitive to environmental issues, but not always fully aware of the role that technology can play in ecological terms. For policymakers, these results indicate that supporting sustainability transitions in the agri-food sector requires not only incentives for technology adoption on the supply side but also demand-side actions aimed at strengthening public understanding, legitimacy, and trust in innovation. Policies that facilitate information transparency and public engagement around enabling technologies may help create more favorable conditions for their diffusion, aligning technological progress with broader environmental and sustainability objectives. Likewise, farmers and primary sector operators, who are often required to meet the demands of an evolving market, can benefit from a better understanding of consumer perceptions, thereby guiding their choices toward production models that integrate innovation with attention to social expectations.

6 | Conclusions

This study contributes to the growing debate on sustainable innovation in agri-food systems by providing empirical evidence on the psychological, social, and cognitive factors shaping consumer acceptance of enabling technologies. From a theoretical perspective, the findings extend existing research on innovation acceptance (Siegrist and Hartmann 2020; Giacalone and Jaeger 2023) by showing that consumer readiness is not driven only by attitudinal orientations, but also by social legitimacy and perceived KN, which emerge as particularly relevant in explaining behavioral intentions. Beyond its theoretical contribution, the study also offers important practical implications. When consumers perceive stronger social legitimacy around enabling technologies and feel more informed about their benefits, firms may face lower market uncertainty and greater incentives to invest in technologically advanced and environmentally sustainable production systems (Finger 2023). In this sense, consumer acceptance becomes a key enabling condition for strategic technology adoption pathways and for the broader transition toward more resilient and environmentally responsible agri-food systems.

Despite its contributions, this research has several limitations. First, the cross-sectional design restricts the ability to establish causal relationships and to capture how perceptions may evolve over time. Moreover, although the dataset is extensive, it focuses solely on Italian consumers, limiting cross-cultural generalization. Although the sample captures substantial sociodemographic variation, it should not be interpreted as fully representative of the Italian population. Another limitation concerns the self-reported nature of the data: Participants' stated intentions do not always translate into actual behaviors, a well-documented phenomenon in food consumption research. Finally, the technologies under consideration were presented in a generic way to ensure neutrality and comparability, but this choice may have reduced the ability to capture more specific and concrete perceptions associated with individual technological solutions (e.g., drones, agricultural robots, or blockchain).

Future research could adopt longitudinal or experimental approaches to assess how intentions evolve over time or in response to targeted informational interventions. In addition, it would be valuable to complement traditional self-reported measures with behavioral methods, such as incentivized experimental auctions or sensory tests in controlled settings, which allow for a more direct and realistic measurement of preferences and willingness to pay, thereby helping to bridge the gap between stated attitudes and actual behaviors. Future investigations might compare perceptions across diverse sociocultural contexts or levels of technological diffusion. Enhancing public understanding and transparency will be essential to foster a sustainable and inclusive digital transition of agriculture. It would also be of interest to examine the role of contextual factors—such as trust in institutions, direct familiarity with innovation, or the social capital of local communities—that may act as facilitators or barriers to acceptance. Finally, future studies could focus on specific enabling technologies—from precision agriculture to robotics, including blockchain and artificial intelligence—to capture potential differences in consumer perceptions and reactions.

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Appendix

TABLE A1 | Full collinearity VIFs for latent constructs—Common method bias test.

Target construct	Max VIF	Mean VIF
INT	1.66	1.23
FTN	2.12	1.37
NEP	2.58	1.52
SN	2.04	1.33
KN	2.26	1.42