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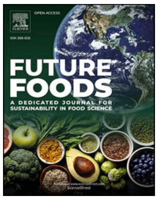

Consumer perceptions and preferences for urban farming, hydroponics, and robotic cultivation: A case study on parsley

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ABSTRACT

Consumer attitudes toward novel fresh herb cultivation methods, including urban farming, hydroponics, and robotic cultivation, were explored among 148 participants in the UK. Urban farming emerged as the preferred method, followed by hydroponics, while robotic cultivation was least favoured. The study tested two hypotheses regarding the influence of environmental concern on acceptance of parsley from the different methods, and the impact of food technology neophobia on acceptance of parsley from hydroponics and robotic cultivation. Consumer levels of environmental concern positively influenced their acceptance of parsley from urban farming, while food technology neophobia negatively impacted the consumer acceptance of hydroponic and robotic cultivation methods. The study underscores the perceived natural elements inherent in these methods. Urban farming seems to align well with consumers' values of nature and sustainability. Tailored messaging highlighting the natural aspects of all these methods, and addressing concerns about the use of technology, may help to bridge the gap between innovation and consumer acceptance, contributing to the delicate balance between tradition and innovation in agricultural strategies. At the same time, however, the study's exploratory nature may limit the generalizability of the results. Future research could broaden the participant sample and explore additional psychological factors shaping attitudes toward novel agricultural techniques.

1. Introduction

In the ever-evolving agricultural landscape, where innovation is intricately interwoven with tradition, a critical issue concerns understanding changing consumer preferences to help guide the evolution of more sustainable farming practices moving forward. This study delves into the current dynamics of consumer attitudes towards novel parsley cultivation methods, seeking to unravel the psychological underpinnings that influence people's preferences in relation to urban farming, hydroponic farming, and robotic cultivation. By delving into current consumer perceptions, we can tailor narratives that resonate with their values, ultimately fostering meaningful climate action.

The agricultural sector is currently undergoing a transformative phase, with a heightened focus on addressing the consequences of climate change (Klerkx and Rose, 2020). In this context, the integration of innovative cultivation methods transcends mere scientific exploration; it emerges as a societal imperative. Nonetheless, the adoption of innovative cultivation methods by farmers largely depends on the ultimate acceptance and demand from consumers (Kühne et al., 2010). Despite agriculture historically being a hub of technological innovation (Andrade et al., 2020; Chavas and Nauges, 2020), consumer reluctance towards embracing new technologies in food production persists (Califano et al., 2023; Fantechi et al., 2024). Unlike other fields, advances in technology related to food show minimal obsolescence over time. Rather than replacing older technologies, new ones tend to build upon and supplement them. Hence, while foods produced via more traditional and familiar methods remain readily accessible, consumers may experience less pressure to quickly embrace innovations in comparison to other industries (Siegrist and Hartmann, 2020). Parsley, a globally popular culinary herb (Spence, 2021), and amongst the top-selling fresh herbs in Europe according to the Centre for the Promotion of Imports (2020), serves in the present study as a vehicle to explore broader consumer dynamics within the realm of agricultural innovation. Parsley can be considered a "low involvement" product within the leafy greens/fresh herbs/vegetable spectrum, as it is often used as an edible garnish, bought frequently with minimal thought and effort. This characteristic

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makes parsley an ideal candidate for investigating consumer preferences related to production techniques, rather than solely focusing on the attributes of the herb itself.

The three cultivation methods under study—urban farming, hydroponic farming, and robotic cultivation—present distinct approaches and can be used for parsley cultivation. Urban farming, for example, can use organic waste materials and composted food waste for cultivation, influencing environmental quality through altered urban-vegetation-atmosphere interactions. It offers numerous advantages (Grebitus et al., 2020), such as enhancing sustainability and local ecosystems (Wakefield et al., 2007), bolstering food security (Sadler, 2016), and promoting healthier diets (Warren et al., 2015). Nonetheless, the approach faces challenges such as land dependency, weather sensitivity, and potential inefficiency when compared to more technologically advanced methods. Urban agriculture can operate on both community and commercial scales (Poulsen et al., 2017).

Hydroponic farming, a soilless cultivation method, leverages a nutrient-rich water solution to directly nourish plant roots. While this method offers precise control over nutrient delivery and environmental conditions, drawbacks may include high energy requirements and initial setup costs, as well as the need for specific skills in managing nutrient solutions (Maucieri et al., 2019). However, well-managed hydroponic operations can have several advantages. For example, the recirculation of water can curtail water usage by up to 95 % relative to traditional field farming (Gilmour et al., 2019), and hydroponics is generally considered an eco-friendly, cost-saving, and highly productive method for vegetable production (Chen et al., 2020; Sharma et al., 2018).

Finally, robotic cultivation integrates mechanical, electrical, and computer engineering to create machines capable of executing complex agricultural tasks autonomously (Charania and Li, 2020). This includes the use of automated platforms equipped with sensors and cameras for precise planting and harvesting activities (Spence, 2020, 2023). The incorporation of advanced robotics and artificial intelligence is anticipated to enhance decision-making at the farm level, enabling condition monitoring and production optimization. This approach aims to facilitate the precise application of inputs for each crop, potentially increasing yields while reducing water usage and greenhouse gas emissions (Linaza et al., 2021). However, despite providing efficiency and autonomy, this method demands a substantial initial investment, skilled maintenance, and is susceptible to technical failure (cf. Spence, 2023).

All three of the methods examined may offer potential enhancements in terms of environmental sustainability. Consumers who are increasingly mindful of the environmental impact of traditional farming practices, may lean towards embracing innovative approaches if they perceive them to be more sustainable (Jürkenbeck et al., 2019). Past studies have indicated that environmental concern is a crucial individual characteristic linked to the acceptance of diverse new food technologies (e.g., Giacalone and Jaeger, 2023; Lombardi et al., 2023).

However, the phenomenon of food technology neophobia, characterized by an aversion to new food technologies (Cox and Evans, 2008), poses a potential barrier to the acceptance of novel farming practices (Vidigal et al., 2015; Wendt and Weinrich, 2023). Elevated levels of food technology neophobia may contribute to consumer reluctance, particularly towards hydroponic and robotic methods, as the perceived complexity and detachment from traditional farming practices of these methods may trigger resistance. Given these premises, the present study hypothesizes that:

H1: Environmental concern positively influences the consumer acceptance of parsley produced through urban farming (a), hydroponics (b), and robotic cultivation (c).

H2: Food technology neophobia negatively impacts consumer acceptance of parsley produced through hydroponics (a) and robotic cultivation (b).

2. Materials and methods

2.1. Participants and procedure

In December 2023, 148 UK participants (*M* of age = 42.07 years; *SD* of age = 12.46 years) were recruited through Prolific to complete an online survey about fresh parsley. The survey was designed to be anonymous to minimize any social desirability biases. All items and questions required a mandatory response to prevent missing data. Before starting the questionnaire, the participants were informed of the anonymity of data collection and signed an informed consent form, declaring they were at least 18 years old.

The questionnaire comprised three main sections. In the first section, the participants were invited to read a concise description of three cultivation methods for fresh herbs, such as parsley. The descriptions for each method were designed by one of the authors with direct experience in these technologies. Their aim was to offer participants a general overview of the methodologies, avoiding any specific framing. Subsequently, they were reviewed and revised by the other authors. Additionally, we made sure that each description contained approximately the same number of words. These descriptions, provided in Table 1, were presented in a randomized order for each participant. Participants were then asked to rate their: 1) willingness to accept each method (e.g., “I am in favour of using Urban Farming Gardens for the cultivation of parsley”); 2) willingness to consume parsley produced by each specific practice (e.g., “I am willing to consume parsley from an Urban Farming Garden”); and 3) willingness to pay a premium for parsley cultivated using each method (e.g., “I am willing to pay a higher price for parsley grown in Urban Farming Gardens”). These items were adapted from Di Vita et al. (2024), with responses collected on a Likert scale ranging from 1 (“Strongly disagree”) to 5 (“Strongly agree”).

The second section of the questionnaire comprised scales designed to measure psychological constructs. Table 2 lists the items used along with the main statistics. Specifically, the Food Technology Neophobia Scale (FTNS; Cox and Evans, 2008) was used to assess participants’ neophobia towards new food technologies. This scale includes 13 items, rated on a

Table 1
Descriptions of the three cultivation methods provided to participants.

Method	Description
Urban farming garden	“Urban Farming Garden uses organic waste materials, composted food waste, and local organic substances to fertilize cultivation beds. This method focuses on using waste streams from cities to grow a variety of crops, including herbs and vegetables. It also incorporates biodiversity by maintaining bees and free-range chickens. The approach is community-oriented, sustainable, and relies on manual labor. However, it requires significant land, is weather-dependent, and may lack the precision of more technologically advanced methods.” (Word count: 74)
Hydroponic farming	“Hydroponic farming is a soilless cultivation method using a nutrient-rich water solution to provide essential nutrients directly to plant roots. This technique allows precise control over nutrient delivery, water usage, and environmental conditions, facilitating efficient and controlled plant growth. It is water-efficient, suitable for year-round cultivation, and ideal for space-constrained urban settings. However, it demands significant energy for system operation, has a high initial setup cost, and requires specific skills for managing nutrient solutions and system controls.” (Word count: 77)
Robotic cultivation	“Robotic cultivation involves the use of automated modular platforms equipped with sensors, cameras, and navigation systems. These robotic systems perform tasks such as precision planting, seeding, weeding, and harvesting. They offer high efficiency, customization, and autonomy with minimal human intervention. This method is data-driven and energy-efficient, contributing to sustainable agriculture. Despite its advantages, it requires a substantial initial investment, skilled maintenance, and is dependent on technology, making it vulnerable to technical failures.” (Word count: 72)

Table 2
Items used with main statistics.

	Item	*M*	*SD*
FTNS_1	There is no sense trying out high-tech food products because the ones I eat are already good enough.	2.63	1.09
FTNS_2	New food technologies are something I am uncertain about.	3.04	1.03
FTNS_3	New foods are no healthier than traditional foods.	3.30	1.01
FTNS_4	The benefits of new food technologies are often grossly overstated.	3.21	0.95
FTNS_5	There are plenty of tasty foods around, so we do not need to use new food technologies to produce more.	2.82	1.15
FTNS_6	New food technologies decrease the natural quality of food.	2.76	1.01
FTNS_7	New food technologies are unlikely to have long term negative health effects. *	2.75	0.91
FTNS_8	New food technologies give people more control over their food choices. *	2.52	0.85
FTNS_9	New products using new food technologies can help people have a balanced diet. *	2.56	0.89
FTNS_10	New food technologies may have long-term negative environmental effects.	3.11	0.96
FTNS_11	It can be risky to switch to new food technologies too quickly.	3.47	0.97
FTNS_12	Society should not depend heavily on technologies to solve its food problems.	3.32	1.16
FTNS_13	The media usually provides a balanced and unbiased view of new food technologies. *	3.49	1.02
NEP_1	We are approaching the limit of the number of people the Earth can support.	3.61	1.05
NEP_2	When humans interfere with nature it often produces disastrous consequences.	3.82	0.93
NEP_3	Humans are seriously abusing the environment.	4.18	0.83
NEP_4	Plants and animals have as much right as humans to exist.	4.18	0.89
NEP_5	Despite our special abilities, humans are still subject to the laws of nature.	4.22	0.73
NEP_6	The Earth is like a spaceship with very limited room and resources.	3.67	1.06
NEP_7	The balance of nature is very delicate and easily upset.	4.00	0.80
NEP_8	If things continue on their present course, we will soon experience a major ecological catastrophe.	3.97	1.04
U_BI_1	I am in favour of using Urban Farming Gardens for the cultivation of parsley.	4.26	0.69
U_BI_2	I am willing to consume parsley that comes from an Urban Farming Garden.	4.32	0.75
U_BI_3	I am willing to pay a higher price for parsley grown in Urban Farming Gardens.	3.18	1.09
R_BI_1	I am in favour of Robotic Cultivation for the cultivation of parsley.	3.45	0.91
R_BI_2	I am willing to consume parsley that comes from Robotic Cultivation.	4.01	0.80
R_BI_3	I am willing to pay a higher price for parsley grown in Robotic Cultivation.	2.32	1.04
H_BI_1	I am in favour of Hydroponic Farming for the cultivation of parsley.	3.61	0.93
H_BI_2	I am willing to consume parsley that comes from Hydroponic Farming.	4.05	0.88
H_BI_3	I am willing to pay a higher price for parsley grown in Hydroponic Farming.	2.62	1.12

Notes: FTNS = Food Technology Neophobia Scale; NEP = New Ecological Paradigm; U_BI = Behavioral Intention towards Urban farming; R_BI = Behavioral Intention towards Robotic cultivation; H_BI = Behavioral Intention towards Hydroponic cultivation; * = item reverse scored.

Table 3
Sample characteristics ($N = 148$).

	Frequency	Percent
Parsley consumption		
Never	9	6.08
Rarely (less than once a month)	65	43.92
Occasionally (1–3 times a month)	63	42.57
Regularly (once a week)	8	5.41
Frequently (2–4 times a week)	3	2.03
Age		
18–24 years	9	6.08
25–34 years	37	25.00
35–49 years	60	40.54
50–64 years	34	22.97
≥ *65 years*	8	5.41
Sex assigned at birth		
Male	74	50.00
Female	74	50.00
Ease of meeting financial obligations		
Very easy	22	14.86
Easy	48	32.43
Manageable	55	37.16
Challenging	19	12.84
Very challenging	4	2.70
Area of residence		
Village with fewer than 1000 inhabitants	12	8.11
Town or city with 1000 to 100,000 inhabitants	76	51.35
City with more than 100,000 inhabitants	60	40.54
Household size		
1	23	15.54
2	60	40.54
3	30	20.27
4	24	16.22
5 or more	11	7.43

Likert scale from 1 (“Strongly disagree”) to 5 (“Strongly agree”), where higher scores indicate more negative attitudes towards new food technologies. The revised New Ecological Paradigm scale (NEP; Dunlap et al., 2000), comprising 8 items rated on a Likert scale from 1 (“Strongly disagree”) to 5 (“Strongly agree”), was used to gauge participants’ environmental concerns.

Finally, the third section requested sociodemographic information from participants, such as sex assigned at birth, age, and household family size (refer to Table 3 for sample characteristics).

2.2. *Statistical analysis*

The empirical analysis used two primary statistical methods. The first involved conducting multiple paired *t*-tests to examine the differences in preferences for parsley produced through urban farming, robotics, and hydroponics. These preferences were measured by three items and their averaged value: attitudes towards the specific method, willingness to consume, and willingness to pay a premium for parsley produced via that method. Thus, *t*-tests for dependent samples were conducted for each item and the average score between them (hereinafter referred to as “behavioral intentions;” BI), representing the dependent variables. To mitigate Type I error due to multiple comparisons, a Bonferroni correction was applied, with α level set to 0.05 before correction. Table 4 illustrates pairwise correlations among the variables included in the study.

The second method used was Partial Least Squares-Structural Equation Modelling (PLS-SEM). This approach was used to explore the impact of NEP and FTNS on behavioral intentions towards each cultivation method (see Fig. 1 for the hypothesized model). PLS-SEM, akin to conventional Structural Equation Modelling (SEM), comprises a measurement (outer) model and a structural (inner) model. The outer model assesses the connections between latent variables and their indicators, while the inner model investigates the relationships among latent constructs (Venturini and Mehmetoglu, 2019). PLS-SEM is known to provide robust estimates, and is preferred to SEM when dealing with small sample sizes and non-normally distributed data (Hair et al., 2019).

After establishing the measurement model, several criteria were used to validate its appropriateness. These criteria comprised factor loadings greater than 0.50, and Cronbach’s α and Rho A exceeding 0.70 (indicator reliability). Convergent and discriminant validity of the constructs were also scrutinized. Convergent validity was assessed by examining the Average Variance Extracted (AVE) of the construct, which should be equal to or greater than 0.50. Discriminant validity was appraised using the Fornell-Larcker criterion, comparing the square root of the AVE with the correlation between latent constructs (Venturini and Mehmetoglu,

Table 4
Correlation matrix of variables.

	1	2	3	4	5	6	7	8	9	10	11
1. Parsley	1										
2. Age	.039	1									
	(0.637)										
3. Man	.079	.110	1								
	(0.343)	(0.184)									
4. Income	.021	.077	.021	1							
	(0.805)	(0.353)	(0.803)								
5. City	**.266**	−0.110	.000	−0.075	1						
	(0.001)	(0.184)	(0.999)	(0.365)							
6. Household	.028	−0.133	−0.100	−0.109	−0.048	1					
	(0.737)	(0.106)	(0.229)	(0.186)	(0.559)						
7. FTNS	−0.048	.088	−0.066	−0.079	−0.024	−0.037	1				
	(0.561)	(0.287)	(0.429)	(0.342)	(0.772)	(0.654)					
8. NEP	−0.084	−0.018	−0.084	.019	.161	−0.070	.042	1			
	(0.312)	(0.827)	(0.313)	(0.816)	(0.051)	(0.399)	(0.616)				
9. BI Urban	**.180**	.055	−0.056	.103	−0.009	.049	−0.039	.107	1		
	(0.028)	(0.509)	(0.502)	(0.215)	(0.917)	(0.556)	(0.635)	(0.194)			
10. BI Hydro	**.202**	−0.059	.061	.059	**.162**	.020	−0.161	.049	.141	1	
	(0.014)	(0.480)	(0.463)	(0.476)	(0.049)	(0.808)	(0.051)	(0.557)	(0.088)		
11. BI Robotic	**.264**	−0.034	.048	**.189**	.003	−0.088	**−0.276**	.079	−0.028	**.439**	1
	(0.001)	(0.685)	(0.560)	(0.022)	(0.976)	(0.286)	(0.001)	(0.338)	(0.740)	(0.001)	

Notes: In bold, correlations significant at least at the 5 % level (*p*-values in parentheses). Parsley = Parsley consumption; Income = Ease of meeting financial obligations; City = City with more than 100,000 inhabitants; Household = Household size; FTNS = Food Technology Neophobia Scale; NEP = New Ecological Paradigm; BI = Behavioral Intentions.

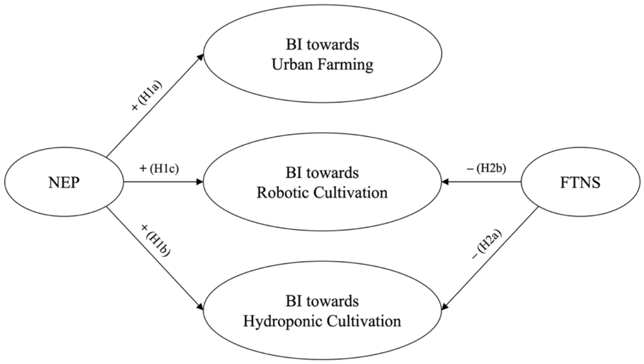

Fig. 1. Hypothesized model. Plus and minus signs indicate the direction of the hypothesized relation, as coded in parentheses. NEP = New Ecological Paradigm; BI = Behavioral Intentions; FTNS = Food Technology Neophobia Scale.

2019). The assessment of the structural model was grounded in the path coefficient values and their statistical significance (Venturini and Mehmetoglu, 2019).

The sample size for this study was determined using both an a priori power analysis conducted in G*Power 3.1 (Faul et al., 2009) and the "10-times rule" method, a widely adopted approach for minimum sample size estimation in PLS-SEM (Hair et al., 2011; Peng and Lai, 2012). According to this rule, the recommended sample size should exceed the total number of paths pointing to a latent variable (or from a latent variable to its indicators, if this number is greater), multiplied by 10 (in this case, 13 items of the FTNS multiplied by 10 equals 130). Additionally, the minimum sample size required for three comparisons for dependent samples was calculated to be 143 to satisfy a level of effect size d_z equal to 0.25, achieving a statistical power $(1 - \beta)$ of 0.80 with $\alpha = 0.017$ (i.e., 0.05 divided by the number of comparisons according to the Bonferroni method). Therefore, with 148 participants, both criteria were satisfied. All statistical analyses were performed using Stata 18.

3. Results

Regarding consumers' preferences for the three proposed methods of parsley cultivation, the results from multiple paired *t*-tests (presented in Table 5) indicated a preference for urban farming, followed by hydroponic and robotic cultivation methods. The latter two were deemed equally unappealing in terms of willingness to accept the technologies and willingness to consume parsley produced by these methods. However, in terms of willingness to pay a premium, parsley produced using robotic cultivation received a significantly lower rating as compared to hydroponic cultivation. Moreover, a clearer hierarchy in preferences was observed when analyzing the mean scores of the three items. Specifically, regarding BI, urban farming received the highest rating, followed by hydroponics, and finally by robotic cultivation (see Fig. 2 for the distributions of BI).

Subsequently, a PLS-SEM was used to assess the roles of FTNS and NEP in explaining people's preferences for each cultivation method. After removing items with factor loadings lower than 0.50, the measurement model (see Table 6) demonstrated satisfactory indicator reliability, with Cronbach's α and Rho A hovering around 0.70. Convergent and discriminant validity were considered robust, as all AVE values exceeded 0.50, surpassing the squared interfactor correlations with the other constructs (see Table 7).

The results of the structural model (Fig. 3) indicated that NEP positively and weakly predicted BI towards urban farming, confirming H1a, but not towards robotic and hydroponic cultivations. Conversely, FTNS was found to be negatively associated with BI towards hydroponic (weakly) and robotic cultivations (moderately), thus confirming H2a and H2b.

4. Discussion

This study explored consumer attitudes toward novel parsley cultivation methods, specifically urban farming, hydroponic farming, and robotic cultivation. The agricultural sector's current transformative phase, driven by the need to address the consequences of climate change, underscores the importance of integrating innovative cultivation methods on a societal level (Di Vita et al., 2024). The findings reported here shed light on consumers' preferences and willingness to accept, consume, and pay a premium for parsley produced through these methods. The hierarchical analysis of preferences revealed a clear pattern, with urban farming leading the hierarchy across all dimensions of behavioral intentions. Hydroponic farming emerged as the second

Table 5

Comparative analysis of consumer behavioral intentions towards different cultivation methodologies.

	Willingness to Accept		Willingness to consume		Willingness to pay a premium		Behavioral intentions	
	Mean	*SE*	Mean	*SE*	Mean	*SE*	Mean	*SE*
Urban	4.26 ^{A}	0.06	4.32 ^{A}	0.06	3.18 ^{A}	0.09	3.92 ^{A}	0.05
Hydroponic	3.61 ^{B}	0.08	4.05 ^{B}	0.07	2.62 ^{B}	0.09	3.43 ^{B}	0.06
Robotic	3.45 ^{B}	0.07	4.01 ^{B}	0.07	2.32 ^{C}	0.09	3.26 ^{C}	0.06

Note: Means sharing a superscript letter within a column are not significantly different at the 5 % level (i.e., $p > .017$ after Bonferroni correction). The analysis was also conducted using a repeated-measures ANOVA, yielding similar results (see Table S1, Supplementary Material).

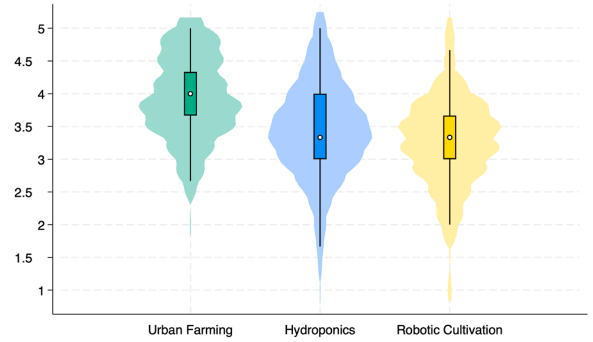

Fig. 2. Distributions of behavioral intentions towards urban farming, hydroponics, and robotic cultivation. The violin plot depicts the median of the distribution (dot within the box), the first and third quartiles (extremities of the box), the remaining distribution excluding outliers (upper and lower lines), and the kernel density (area around the box) for each cultivation method.

Table 6

Measurement model results of PLS-SEM with standardized loadings.

	U_BI	R_BI	H_BI	FTNS	NEP
U_BI_1	.831				
U_BI_2	.825				
U_BI_3	.677				
R_BI_1		.901			
R_BI_2		.797			
R_BI_3		.565			
H_BI_1			.864		
H_BI_2			.841		
H_BI_3			.665		
FTNS_1				.840	
FTNS_2				.730	
FTNS_5				.722	
FTNS_6				.670	
FTNS_9				.647	
NEP_2					.632
NEP_4					.727
NEP_5					.792
NEP_8					.698
Cronbach's α	.678	.648	.715	.779	.689
Rho A	.676	.726	.766	.809	.713

Notes: U_BI = Behavioral Intentions towards Urban farming; R_BI = Behavioral Intentions towards Robotic cultivation; H_BI = Behavioral Intentions towards Hydroponic cultivation; FTNS = Food Technology Neophobia Scale; NEP = New Ecological Paradigm; Items dropped due to factor loadings lower than 0.50: FTNS_3, FTNS_4, FTNS_7, FTNS_8, FTNS_10, FTNS_11, FTNS_12, FTNS_13, NEP_1, NEP_3, NEP_6, NEP_7.

choice, while robotic cultivation received the least favorable responses. The literature indicates that urban farming is generally well accepted by consumers (Sroka et al., 2021). The observed preference for urban farming is also consistent with the results of Giacalone and Jaeger's cross-national survey (Giacalone and Jaeger, 2023). Their study highlighted that urban-farmed vegetables, along with vegetables packaged in a modified atmosphere, were associated with significant consumer acceptance. It is noteworthy that urban farming can be integrated with hydroponic cultivation, the second preferred method amongst consumers in this study. Farmers can strategically position high-yielding hydroponic units near population centers, thereby minimizing transit time and nutrient loss during shipment (Gilmour et al., 2019). Such integration is likely to enhance consumer acceptance for both methodologies.

Table 7

Fornell-Larcker criterion for evaluating discriminant validity in the measurement model of PLS-SEM (comparison of squared interfactor correlation and AVE).

	U_BI	R_BI	H_BI	FTNS	NEP
U_BI	1.000				
R_BI	0.000	1.000			
H_BI	0.019	0.173	1.000		
FTNS	0.001	0.165	0.042	1.000	
NEP	0.046	0.000	0.004	0.007	1.000
AVE	0.610	0.589	0.632	0.526	0.510

Notes: U_BI = Behavioral Intentions towards Urban farming; R_BI = Behavioral Intentions towards Robotic cultivation; H_BI = Behavioral Intentions towards Hydroponic cultivation; FTNS = Food Technology Neophobia Scale; NEP = New Ecological Paradigm.

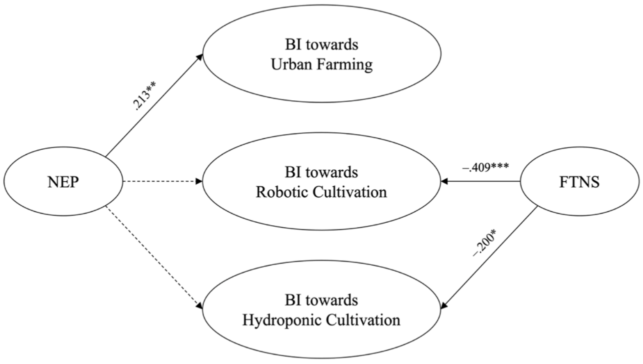

Fig. 3. Structural model results of PLS-SEM. The arrows in the diagram denote standardized direct effects. Dashed arrows indicate effects that are not significantly different from zero ($p > .05$), while solid arrows represent significant effects at * $p < .05$, ** $p < .01$, and *** $p < .001$. NEP = New Ecological Paradigm; BI = Behavioral Intentions; FTNS = Food Technology Neophobia Scale. Adjusted R^2 for: Urban Farming = 0.033; Robotic Cultivation = 0.154; Hydroponic Cultivation = 0.030.

Importantly, the results also highlighted the influence of psychological factors, namely food technology neophobia (measured through the FTNS) and environmental concerns (measured through the NEP), on consumer acceptance. NEP positively predicted behavioral intentions toward urban farming, indicating that individuals with stronger environmental concerns were more likely to favor this cultivation method. However, contrary to the hypothesis, NEP did not predict behavioral intentions toward hydroponic and robotic cultivations. Previous work has shown that the perceived sustainability of vertical farming systems is a major driver of its acceptance (Jürkenbeck et al., 2019). The absence of associations between NEP and hydroponic and robotic cultivation may suggest that participants did not perceive these methods in terms of environmental sustainability, unlike urban farming. This further implies that such methods were not perceived as any more or less sustainable than traditional farming practices. However, additional research is needed in order to comprehensively understand the complexities of consumers' sustainability perception concerning these cultivation methods. Additionally, Freire et al. (2021) propose that alternative instruments, such as the Ecologically Conscious Consumer Behavior scale (Roberts, 1996), might provide better precision in measuring ecological concerns compared to NEP. They also emphasized the necessity for further research in scale development to create more appropriate measurement tools.

On the other hand, FTNS exhibited a negative association with behavioral intentions toward robotic and hydroponic cultivation, suggesting that individuals with higher neophobia levels were less inclined to accept and consume parsley produced through these methods. This aligns with literature showing that food technology neophobia is a significant barrier to the acceptance of new food products and technologies (Wendt and Weinrich, 2023).

Finally, it is noteworthy that NEP and FTNS distinctly predicted the cultivation methods under study, highlighting what appears to be the perceived natural and unnatural elements inherent in these methods. Along with the results underscoring the absolute preference for urban farming, such a pattern suggests that among the proposed methods, it was perhaps perceived as the most "natural". Indeed, food technology neophobia seems to be intricately connected to a desire "to return to the naturalness and purity of food" (Verneau et al., 2014). Although the construct of naturalness is highly abstract and challenging to quantify and measure (Meyer-Höfer et al., 2015; Siipi, 2013), consumers perceive it as an extremely desirable food attribute (Román et al., 2017). Prior research suggests that the preference for what is considered "natural" stems from an inherent belief that it aligns with a fundamental sense of correctness, extending beyond mere logical consequences and encapsulating a broader set of attributes, notably intertwining with perceptions of healthiness and environmental friendliness (Rozin, 2005; Rozin et al., 2004; Verneau et al., 2014; Zamparo et al., 2023). Hence, farmers and manufacturers face pressure to eliminate those processes that are perceived as "unnatural" (Evans et al., 2010). Previous research indicates that consumers' perceptions of naturalness are influenced more by the process than by the content (cf. Román et al., 2017). Urban farming, with its focus on organic waste, community engagement, and biodiversity, seems to align closely with consumers' values and the "natural-is-better" heuristic (Siegrist and Hartmann, 2020). However, as noted by Román et al. (2017), it is advisable for the food industry to integrate communication strategies early in the development of products or technologies. Rather than solely investing in foods already perceived as natural, these strategies should aim to evoke positive associations with foods produced via innovative methods and/or technologies. For example, robotic beddings, the least favored method in this study, can simulate natural plant stresses, such as those experienced in outdoor conditions, which are absent in indoor cultivation (Herdenstam et al., 2022). Leveraging such narratives in communication strategies could strengthen the association with naturalness.

Therefore, the implications of the present study extend to the delicate balance between innovation and tradition in terms of agricultural strategies. Recognizing that all three methods can be considered environmentally friendly to varying extents, framing cultivation practices within a broader narrative of nature and sustainability becomes crucial. Past research has demonstrated that accurately framing information about new food technologies in their early phases can significantly enhance their acceptance (e.g., Fantechi et al., 2024). Hence, tailored messages that accentuate the natural elements of urban farming, address concerns about extensive technology use in hydroponic and robotic methods, and emphasize their connection with nature could effectively bridge the gap between innovation and consumer acceptance.

5. Conclusions

This study explores the complex interplay between psychological factors, consumer preferences, and the perceived natural elements in the context of agricultural innovation. Understanding the narrative surrounding agricultural practices and its connection to consumer acceptance is paramount for the successful implementation of future cropping systems. Our findings offer actionable guidance for stakeholders who want to promote sustainable and accepted farming practices in the changing landscape of consumer attitudes. At the same time, however, the present study also has some limitations that should be acknowledged. The explorative nature of the study and the focus on UK participants, with older consumers underrepresented, may reduce the generalizability of the results. Future research could build on the findings of the present study by including a more diverse and representative sample of participants and examining additional psychological factors that may shape consumer attitudes. In this context, delving deeper into whether general food neophobia, the reluctance to try new foods, moderates the relationship between the technology used and the acceptance of specific foods could be beneficial.

Furthermore, future research could investigate the role of sensory properties of parsley (and/or other herbs) produced with different methods in influencing attitudes toward agricultural innovation. For instance, it would be interesting to explore whether farming method affects the expected and/or actual taste of parsley under blind and known conditions, given that appropriate stressing of leafy greens/herbs can enhance their flavor profile (Spence, 2020). Such a consideration might hint at the importance of testing other leafy green herbs that do differ more markedly in terms of their flavor profile than parsley, which is mostly a garnish, rather than necessarily a food element whose individual qualities are appreciated (or not). Consider here only how rocket (rucola) varies markedly in terms of its pepperiness (Spence, 2020). That is, nudging consumers to novel, and more sustainable, farming practices may be easier to achieve in those cases where a sensory advantage, in terms of sensory qualities and/or consistency can be delivered (Song et al., 2022).

Finally, future research could integrate the results of this study with findings from sensory, culinary, and nutrition studies (Herdenstam, 2004; Herdenstam et al., 2022; Seeburger et al., 2022) to provide a more holistic understanding of consumer preferences, nutritional value, sensory appeal, and culinary versatility. Such a comprehensive approach could better support future innovations in farming by developing a more effective narrative for marketing and promoting novel sustainable food systems, emphasizing a balance between health benefits, sensory satisfaction, and culinary adaptability.

CRediT authorship contribution statement

Giovanbattista Califano: Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Anders Crichton-Fock:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Charles Spence:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization.

Declaration of competing interest

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

Data availability

Data will be made available on request.

Ethical statement

Participants gave informed consent via the statement "I am aware that my responses are confidential, and I agree to participate in this survey" where an affirmative reply was required to enter the survey. They were able to withdraw from the survey at any time without giving a reason.

This study has been reviewed by, and received ethics clearance through, a subcommittee of the University of Oxford Central University Research Ethics Committee [R85145/RE001].

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.fufo.2024.100353.

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