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Consumer Perception and Willingness to Pay for Hydroponically Grown Vegetables in Urban India

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Abstract

The imperative for sustainable and efficient food production systems has intensified in response to rapid urbanization, population growth, and resource depletion. Hydroponic farming has emerged as a viable alternative to conventional soil-based agriculture, offering advantages such as controlled growing environments, reduced chemical dependency, and efficient resource utilization. Despite these technological merits, consumer acceptance remains a critical determinant of commercial viability. This study examines consumer perception and willingness to pay (WTP) for hydroponically grown vegetables among urban Indian consumers. Based on primary data collected from 136 respondents through a structured questionnaire, the study analyzes the influence of consumer awareness, product perception, health consciousness, environmental attitude, price sensitivity, and purchase intention on WTP. Descriptive analysis, correlation, and regression techniques were employed for data analysis. Findings indicate that awareness and familiarity with hydroponic farming are critically low, resulting in uncertain or negative perceptions regarding health benefits, safety, quality, and naturalness. A notable paradox exists: consumers exhibit strong health consciousness (91.9%) and environmental awareness (94.9%), yet do not associate these values with hydroponic produce. Price sensitivity is high, with most respondents unwilling to pay more than a 10% premium. However, 87.5% of respondents expressed conditional purchase intention when product benefits were clearly communicated. The study concludes that consumer education and effective benefit communication are central to bridging the awareness-behavior gap and enhancing WTP for hydroponic vegetables in urban Indian markets.

Keywords: Hydroponic vegetables; Consumer perception; Willingness to pay; Urban India; Sustainable agriculture; Health consciousness

INTRODUCTION

The global food system is confronting unprecedented pressures arising from demographic expansion, accelerating urbanization, climate volatility, and diminishing natural resources. According to the Food and Agriculture Organization (FAO, 2017), the world's population is projected to reach approximately 9.7 billion by 2050, necessitating a near 70% increase in food production under increasingly constrained land and water availability. In this context, hydroponic farming—defined as the soilless cultivation of plants through nutrient-rich aqueous solutions in controlled environments—has attracted growing attention as a viable and scalable alternative to conventional agriculture (Sharma et al., 2018).

Hydroponics offers several documented advantages: up to 90% reduction in water consumption relative to soil-based farming, reduced reliance on pesticides, year-round production independent of climatic conditions, and space-efficient vertical cultivation suited to urban environments (Lee & Bovay, 2025). Despite these benefits, the commercial success of hydroponic produce is contingent not merely on production efficiency, but fundamentally on consumer acceptance and demand.

Consumer behavior toward novel food technologies is shaped by a complex interplay of cognitive, emotional, and cultural factors. Perceptions of healthiness, safety, naturalness, and environmental sustainability are key antecedents of food purchasing decisions (Siegrist, 2008; Roman, 2017). In the Indian urban context, where awareness of hydroponic farming remains nascent, understanding how consumers perceive and value such products is particularly critical for market development.

Despite a burgeoning body of international research on hydroponic consumer behavior, empirical studies focused on India—the world's second most populous nation undergoing rapid urbanization and nutritional transition—remain scarce. This study addresses that gap by examining consumer perception and WTP for hydroponically grown vegetables among urban Indian consumers, with specific attention to the role of awareness, health consciousness, environmental attitudes, and price sensitivity.

RESEARCH OBJECTIVES

The primary objective of this study is to examine consumer perception and willingness to pay for hydroponically grown vegetables among urban consumers in India. The specific objectives are:

1. To assess the level of consumer awareness and familiarity with hydroponic farming.
2. To analyze consumer perception of hydroponic vegetables in terms of health benefits, safety, environmental friendliness, quality, and naturalness.
3. To evaluate the influence of health consciousness and environmental awareness on consumer attitudes toward hydroponic produce.
4. To assess the impact of price perception on consumer WTP for hydroponic vegetables.
5. To identify the key factors that significantly influence consumer WTP and purchase intention.

THEORETICAL FRAMEWORK

This study is grounded in four established theoretical frameworks that collectively explain consumer acceptance of innovative food products.

The Theory of Planned Behavior (TPB; Ajzen, 1991) posits that behavioral intentions—and ultimately behavior—are determined by attitudes toward the behavior, subjective norms, and perceived behavioral control. In this context, consumer attitudes toward hydroponic vegetables (shaped by perceptions of health, safety, and environmental benefits), social norms around sustainable consumption, and control factors such as product availability and affordability are expected to influence purchase intention and WTP.

The Value-Attitude-Behavior (VAB) Model (Homer & Kahle, 1988) proposes that personal values influence attitudes, which in turn drive behavior. Consumers who prioritize health and sustainability are expected to hold more favorable attitudes toward hydroponic produce. However, this study anticipates a disruption in the value-attitude link due to low awareness, wherein strongly held values fail to manifest as positive product perceptions.

Perceived Value Theory (Zeithaml, 1988) frames consumer choice as a trade-off between perceived benefits and perceived costs. For hydroponic vegetables, perceived benefits encompass

safety, nutritional quality, and sustainability, while perceived costs are primarily economic. WTP is operationalized as the maximum price a consumer would accept given the perceived benefit-cost ratio.

Diffusion of Innovation Theory (Rogers, 1962) contextualizes hydroponic produce as an innovative product at an early stage of market diffusion. The majority of urban Indian consumers are hypothesized to be in the awareness or knowledge stage, with only a small segment constituting early adopters. Accelerating diffusion requires targeted strategies to reduce perceived uncertainty and enhance relative advantage.

LITERATURE REVIEW

Consumer acceptance of hydroponically grown vegetables has been examined across diverse global contexts. Naydenova (2025) identified psychological barriers including food neophobia and the perception of reduced naturalness as key determinants of limited hydroponic popularity, with over 50% of respondents in her study associating hydroponic produce with lower naturalness. Jiang (2025), analyzing post-pandemic Chinese consumers, documented a technology-perception and eco-identity model in which environmental awareness drives adoption, while price acts as a significant moderating barrier. The study confirmed an attitude-behavior gap, particularly among lower-income segments.

Fahlevi (2024) established through Structural Equation Modeling (SEM) that consumer awareness, health consciousness, and environmental concern each significantly and positively influence WTP for hydroponic products, with awareness serving as the central driver that shapes downstream health and environmental values. D'Amico (2024), studying hydroponic tomatoes in the European context, found that certifications emphasizing zero residue and sustainability substantially increased WTP among informed consumers. Similarly, Saediman (2024) found that Indonesian consumers held strongly positive health and environmental perceptions of hydroponic vegetables, though practical barriers including price and availability moderated actual purchase behavior.

Gilmour (2018) conducted a non-hypothetical choice experiment demonstrating that consumers unaware of hydroponic benefits required price discounts to choose hydroponic lettuce, while exposure to information about environmental and safety advantages eliminated this discount requirement—underscoring information provision as a critical lever. Califano (2024) reported a clear consumer preference hierarchy in the UK: urban farming > hydroponics > robotic cultivation, with food technology neophobia negatively influencing hydroponic acceptance. Roman (2017) documented the pervasive influence of food naturalness on consumer decisions across international markets, reinforcing that any departure from traditional farming methods generates skepticism.

In the Indian context, Paul et al. (2018) and Yadav & Pathak (2017) established that health consciousness and environmental awareness are significant drivers of green product consumption, providing the theoretical groundwork for extending such analyses to hydroponic produce. Spendrup (2024) found that climate change awareness positively correlated with willingness to consume hydroponic produce, while food neophobia negatively affected acceptance—findings with clear relevance for Indian urban

consumers increasingly exposed to environmental discourse.

Collectively, the literature identifies low awareness, negative naturalness perception, price sensitivity, and the attitude-behavior gap as universal challenges for hydroponic market penetration, while also affirming the potential of health consciousness, environmental values, and targeted information as drivers of consumer acceptance.

RESEARCH METHODOLOGY

Research Design and Data Collection

This study adopts a quantitative, descriptive-analytical research design. Primary data were collected through a structured self-administered questionnaire distributed via online platforms to urban vegetable purchasers. A non-probability convenience sampling technique was employed. The final usable sample comprised 136 respondents, with 89% residing in urban areas and 79.4% actively involved in household vegetable purchasing decisions, confirming sample relevance.

Variables of the Study

The dependent variable is Willingness to Pay (WTP), operationalized as the respondent's readiness to purchase hydroponic vegetables and the price premium they would accept (Same price / Up to 10% / 10–25% / More than 25% above conventional vegetable prices). Independent variables include: (1) Consumer Awareness — familiarity with hydroponic concepts; (2) Consumer Perception — Likert-scale assessments of health benefits, safety, environmental friendliness, quality, and naturalness; (3) Health Consciousness — concern for health and preference for nutritious food; (4) Environmental Awareness — support for sustainable farming practices; (5) Price Perception — price comparison behavior; and (6) Purchase Intention — conditional willingness to choose hydroponic vegetables when benefits are communicated.

Instrument Design and Analysis Techniques

The questionnaire incorporated Likert-scale items (1 = Strongly Disagree to 5 = Strongly Agree) for perception variables, binary (Yes/No) items for awareness and behavioral variables, and categorical items for demographic and WTP data. Data were analyzed using descriptive statistics (frequency distributions, percentage analysis), correlation analysis to examine inter-variable relationships, and multiple regression analysis to identify significant predictors of WTP. A significance threshold of $p < 0.05$ was applied for hypothesis testing.

DATA ANALYSIS AND RESULTS

Demographic Profile

The sample comprised 60.3% male and 39.7% female respondents. A significant majority (69.1%) belonged to the 18–25 age group, followed by 29.4% in the 26–35 cohort. Income distribution skewed toward lower and middle-income groups, with 54.4% earning below ₹20,000 per month and 38.2% in the ₹20,000–₹50,000 bracket. This income profile has direct implications for price sensitivity analysis.

Awareness and Familiarity

Awareness levels were critically low. Only 28.7% of respondents had heard of hydroponic vegetables, and 70.6% reported being entirely unfamiliar with hydroponics. Among those with any awareness, only 4.4% described

themselves as moderately aware and 2.2% as very aware. Consistent with these figures, merely 9.6% of respondents had ever purchased hydroponic vegetables.

Consumer Perception Analysis

Consumer perception of hydroponic vegetables was predominantly negative or uncertain across all evaluated dimensions. Regarding health benefits, 55.9% disagreed or strongly disagreed that hydroponic vegetables are healthier than conventional produce, while only 19.1% agreed. Safety perception was more skeptical, with 54.4% disagreeing or strongly disagreeing that hydroponic vegetables are safe to consume. Environmental friendliness was similarly unrecognized, with 55.9% expressing disagreement. Product quality and freshness were doubted by 54.4% of respondents. The most pronounced finding was the naturalness concern: 55.8% agreed or strongly agreed that hydroponic vegetables are less natural than soil-grown alternatives, representing a significant psychographic barrier.

Health Consciousness and Environmental Awareness

A striking divergence was observed between consumer values and product perception. An overwhelming 91.9% of respondents expressed concern for their health, and 94.9% indicated a preference for nutritious food. Equally, 94.9% reported support for sustainable farming practices. These high levels of health consciousness and environmental awareness represent an untapped reservoir of consumer motivation that is not presently channeled toward hydroponic products.

Price Sensitivity and Willingness to Pay

Price sensitivity was high across the sample, consistent with the predominantly lower-income demographic. Eighty-nine percent of respondents reported that they compare prices before purchasing vegetables. Regarding WTP, 37.5% were willing to pay only the same price as conventional vegetables, and the largest segment (42.6%) would accept up to 10% more. Only 15.4% expressed willingness to pay a 10–25% premium, and a mere 4.4% would accept more than 25% above conventional prices.

Purchase Intention

Despite low awareness and weak perceptions, 87.5% of respondents indicated they would choose hydroponic vegetables over conventional alternatives if the benefits were clearly communicated. This finding—the most important in the dataset—demonstrates that consumer resistance is rooted in information deficiency rather than dispositional rejection of hydroponic produce.

DISCUSSION

The findings of this study reveal a coherent and concerning pattern: urban Indian consumers possess the motivational prerequisites for hydroponic adoption—strong health consciousness and genuine environmental concern—yet remain largely uninformed about hydroponic farming and consequently hold weak or negative product perceptions. This configuration closely mirrors what Fahlevi (2024) and Jiang (2025) have described as a values-awareness disconnect, where attitudes cannot form without foundational knowledge.

The low awareness figures (28.7% having heard of hydroponics) contextualize

the negative perception scores. Consumers are not rejecting hydroponic vegetables based on informed evaluation; rather, they are responding to uncertainty and unfamiliarity with skepticism—a well-documented response to novel food technologies (Siegrist, 2008). The naturalness concern, with 55.8% perceiving hydroponic vegetables as less natural, aligns with Roman's (2017) finding that naturalness is a consistent and powerful driver of food rejection across cultures. The absence of soil in the cultivation process appears to activate an unnaturalness heuristic that overrides other potential quality signals.

The attitude-behavior gap is empirically evident in this study. Consumers who express strong support for sustainability and nutrition do not translate these values into positive perceptions or purchasing behavior toward hydroponic vegetables. This finding extends the VAB model (Homer & Kahle, 1988) by demonstrating that the value-to-attitude link is contingent on sufficient product knowledge. Without awareness, values remain latent and do not activate corresponding attitudes.

The WTP distribution—with 80.1% of respondents limited to accepting a 10% or lower premium—reflects both economic constraints and weak perceived value. The income-concentrated sample (92.6% earning below ₹50,000 per month) inherently limits premium acceptance. However, even accounting for income effects, the perceived benefit-to-cost ratio is insufficient to motivate higher WTP, consistent with Perceived Value Theory. This implies that the strategic imperative is not primarily to reduce prices, but to increase perceived benefits through information and certification.

The conditional purchase intention finding (87.5%) is the most strategically significant result. It establishes that the hydroponic market in urban India faces an education challenge, not a preference challenge. This aligns with Gilmour (2018), who demonstrated that information provision alone could shift consumer preferences from requiring a price discount to indifference between hydroponic and conventional lettuce. The implication is that awareness investments by producers and policymakers have high marginal returns in this context.

HYPOTHESIS TESTING

Six hypotheses were formulated and tested through correlation and regression analysis at a significance level of $p < 0.05$:

H1 (Consumer awareness → WTP): Supported. Respondents with greater familiarity reported higher WTP, confirming awareness as a foundational driver. The correlation between awareness and WTP was positive and statistically significant, supporting the theoretical position that knowledge reduces uncertainty and enhances perceived value.

H2 (Consumer perception → WTP): Supported. Perception across health, safety, environmental, quality, and naturalness dimensions significantly influenced WTP. Negative perceptions—particularly regarding naturalness and safety—acted as strong suppressors of WTP, while the small segment holding positive perceptions demonstrated higher premium acceptance.

H3 (Health consciousness → WTP): Partially supported. While health consciousness was near-universal in the sample (91.9%), its direct effect on WTP was moderated by the awareness deficit. Consumers who are health-conscious but

unaware of hydroponic health benefits cannot translate this value into purchasing intent. The relationship becomes significant only when awareness is introduced as a mediator.

H4 (Environmental awareness → WTP): Partially supported. Similarly, broad environmental concern does not translate into WTP for hydroponic products without a clear perceived link between hydroponic farming and environmental sustainability. The disconnection between environmental values and environmental perception of hydroponic produce partially attenuates this relationship.

H5 (Price perception → WTP): Supported. Price sensitivity significantly and negatively influenced WTP, with highly price-sensitive respondents concentrated in the same-price and up-to-10% premium categories. The predominance of lower and middle-income respondents amplified this effect.

H6 (Purchase intention → WTP): Supported. Conditional purchase intention was the strongest direct predictor of WTP. Respondents expressing willingness to choose hydroponic vegetables when benefits are communicated were significantly more likely to indicate premium acceptance, confirming the centrality of information in the purchase decision process.

CONCLUSION

Summary of Key Findings

This study provides the first comprehensive empirical analysis of consumer perception and WTP for hydroponically grown vegetables in urban India. The central finding is that hydroponic vegetables face an information barrier rather than a preference barrier. Urban Indian consumers exhibit strong health consciousness (91.9%) and environmental awareness (94.9%), possess the motivational substrate for hydroponic adoption, and demonstrate strong conditional purchase intention (87.5%) when product benefits are communicated. However, critically low awareness (28.7% basic awareness; 6.6% moderate-to-high familiarity), predominantly negative perceptions across key product attributes, and high price sensitivity collectively constrain current WTP to modest premium ranges.

Theoretical Implications

The study extends existing theoretical frameworks in several meaningful ways. First, it empirically validates a values-awareness-attitude pathway that refines the VAB model, demonstrating that consumer values cannot activate favorable attitudes toward novel food technologies in the absence of foundational product knowledge. Second, it enriches TPB applications to sustainable food consumption by identifying awareness as a necessary precondition for translating positive attitudes into purchase behavior. Third, it contributes to Diffusion of Innovation theory by characterizing urban Indian hydroponic consumers as predominantly in the knowledge and persuasion stages of diffusion, with early adopter characteristics confined to a small, educated, health-conscious minority.

Managerial Implications

For producers, retailers, and policymakers seeking to develop the hydroponic vegetable market in India, the study offers actionable strategic guidance. Consumer education campaigns—delivered through social media, in-store demonstrations, and digital platforms—represent the highest-return investment given the strength of conditional purchase intention. Marketing communications

should explicitly address the naturalness misconception by transparently explaining the hydroponic production process and emphasizing product safety and quality assurance. Certification schemes (e.g., pesticide-free, zero-residue certifications) can serve as trust-building signals analogous to those documented in European markets (D'Amico, 2024). Pricing strategies should initially target the 10% premium range accepted by the largest consumer segment, with scope for upward adjustment as awareness and perceived value increase. Younger urban consumers (18–35) represent the most receptive initial target segment and should anchor early adoption marketing efforts.

Limitations and Future Research

This study is subject to several limitations. Convenience sampling restricts generalizability, and the predominance of younger respondents (18–25: 69.1%) may not reflect broader urban population attitudes. The reliance on self-reported data introduces potential social desirability bias, particularly for health and environmental attitude items. The geographic focus on urban areas excludes semi-urban and rural consumer segments where evolving food trends may differ. Future research should employ larger probability samples with greater demographic diversity, incorporate qualitative methodologies (focus groups, in-depth interviews) to explore the mechanisms underlying the naturalness perception barrier, and conduct longitudinal studies to track attitude change following awareness interventions. Comparative analyses of hydroponic versus organic versus conventional produce perception would further clarify competitive positioning opportunities.

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Table 1: Consumer Awareness and Familiarity with Hydroponics

Variable	Response	Frequency (n=136)	Percentage (%)
Heard of hydroponic vegetables	Yes	39	28.7
	No	97	71.3
Familiarity level	Not aware	96	70.6
	Slightly aware	31	22.8
	Moderately aware	6	4.4
	Very aware	3	2.2
Ever purchased hydroponic vegetables	Yes	13	9.6
	No	123	90.4

Table 2: Consumer Perception of Hydroponic Vegetables (Likert Scale 1–5)

Perception Attribute	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
Healthier than conventional	26.5%	29.4%	25.0%	5.9%	13.2%
Safe to consume	38.2%	16.2%	26.5%	5.9%	13.2%
Environmentally friendly	32.4%	23.5%	23.5%	7.4%	13.2%
Fresh and high quality	36.0%	18.4%	25.0%	7.4%	13.2%
Less natural than soil-grown*	11.8%	5.9%	26.5%	25.7%	30.1%

**Reversed item: higher agreement indicates negative perception of naturalness*

Table 3: Willingness to Pay Premium for Hydroponic Vegetables

WTP Category	Frequency (n=136)	Percentage (%)
Same price only	51	37.5
Up to 10% more	58	42.6
10%–25% more	21	15.4
More than 25% extra	6	4.4

Table 4: Summary of Hypothesis Testing Results

Hypothesis	Statement	Result
H1	Consumer awareness has a significant positive influence on WTP	Supported
H2	Consumer perception has a significant influence on WTP	Supported
H3	Health consciousness has a significant positive influence on WTP	Partially Supported
H4	Environmental awareness has a significant positive influence on WTP	Partially Supported
H5	Price perception has a significant negative influence on WTP	Supported
H6	Purchase intention has a significant positive influence on WTP	Supported