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Consumer perception and willingness to pay a premium for hydroponic vegetables in Urban India: Evidence from empirical investigation

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Abstract

Hydroponic cultivation is emerging rapidly as a response to land and water constraints in urban India, yet the commercial success of this segment depends on whether consumers are aware of, positively perceive and are willing to purchase hydroponically grown produce. This study examines the consumer awareness, perception, willingness to pay premium and the constraints faced in purchase by urban consumers towards hydroponic vegetables in Hyderabad city. A descriptive, cross-sectional survey was administered to 200 urban consumers selected through convenience sampling across fifteen retail outlets using a structured interview schedule. Percentage analysis, cross-tabulation, chi square test of independence and the Garrett's ranking technique were used to analyse the data given by respondents. Results indicate a moderate overall level of consumer awareness, with respondents most familiar with the soil-free nature of cultivation but comparatively unaware of local market availability. Perception towards hydroponic vegetables was favourable overall, driven primarily by beliefs about environmental sustainability and pesticide-free safety, while taste perception remained neutral. The chemical-free status of the produce, followed by price-affordability and health benefits, emerged as the strongest drivers of purchase intention, while accessibility and social recommendation ranked lowest. A majority of respondents indicated they would prefer hydroponic vegetables over conventional produce if priced similarly and supermarkets emerged as the preferred purchase channel. Gender, age, educational qualification and occupation showed no statistically significant association with either awareness or perception. The findings suggest that clearer communication of product safety credentials and improved retail visibility, rather than demographic targeting, are the most effective levers for strengthening purchase intention among urban consumers.

Keywords: Hydroponic vegetables, consumer awareness, consumer perception, willingness to pay, urban consumers, purchase constraints

1. Introduction

Agriculture is increasingly challenged by rapid growth of urbanization, declining availability of arable land and growing water scarcity, particularly in densely populated cities across different developing countries. India faces these pressures more intensely than many other nations, as it accounts for approximately 2.4% of the world's agricultural land while supporting nearly 18% of the world's population. Controlled Environment Agriculture, particularly hydroponic cultivation has emerged as a response to these challenges. By growing crops without soil, hydroponic enables efficient water use, minimises dependence of large acres of land for production by using vertical spaces and facilitates year-round production close to urban consumers. Globally, the hydroponics market was valued at approximately USD 6.57 billion in 2026 and is projected to reach USD 15.64 billion by 2033 (*Coherent Market Insights*, 2026) ^[3] The Indian market is expected to grow even more rapidly, from an estimated USD 199.52 million in 2025 to a projected value nearly USD 1365.61 million by 2033 (*Data M Intelligence*, 2026) ^[5]

Despite these technological innovations in agriculture, the commercial success of hydroponic produce depends not only on production efficiency alone but on social and market acceptance. Hydroponic produce is commonly marketed as a premium product on the assumption that consumers will pay more for the perceived health benefits, superior quality and environmentally sustainable production methods. However, empirical evidences examining whether consumers are genuinely willing to pay a premium for these attributes remains limited, particularly in emerging economies.

Willingness to pay (WTP) a premium for hydroponic produce has been studied across several developed nations and South-East Asian markets, producing generally favourable but context-specific findings. Narine reported that consumers from Trinidad were willing to pay higher prices for hydroponic tomatoes when they perceived them as healthier, with greater consumer knowledge leading to higher WTP. Similarly, in United States, Gilmour (2018) ^[10] found that a positive economic value to hydroponic lettuce and consumer preferences for hydroponic produce were distinct from preferences associated with organic certification. Huang

(2019) ^[11] observed that while over half of consumers surveyed appreciated plant factory production, a considerable share remained concerned about environmental pollution and food safety, whereas association with research institutions increased consumer confidence. Likewise, studies conducted in Europe found that familiarity with environmentally friendly production systems, income and education characteristics of consumers significantly affected willingness to pay premium for hydroponic tomatoes (D'Amico *et al.*, 2024) ^[4].

Some literatures have highlighted a noticeable gap between favourable consumer attitude and actual purchasing behaviour. Fahlevi *et al.* (2024) ^[8] found that awareness was positively influenced both environmental concerns and health consciousness among Indonesian consumers, which significantly enhanced willingness to purchase hydroponic vegetables. However, Saediman *et al.* (2024) ^[19] reported that consumers have acknowledged the health benefits of hydroponic produce, while high prices and limited availability remained as significant barriers to purchase. Similarly, Balqiah concluded that purchase intention was driven by health concern rather than environmental concern and the willingness to pay decreased with increasing consumption frequency. Papilaya *et al.* (2022) ^[18] and Widodo *et al.* (2022) ^[20] both confirmed that produce quality and price were the major drivers of purchase decisions among Indonesian consumers, while Amalia *et al.* (2025) ^[1] found that among income, price and store location, only location had a significant effect on purchase decisions highlighting the importance of accessibility. Gianina *et al.* (2024) ^[9] and Kurniawan *et al.* (2023) ^[17] emphasized freshness and social media had an important part in influencing consumers awareness and purchases decisions. Furthermore, Jiang *et al.* (2025) ^[13] described that a "green consumption paradox" in post pandemic China, where positive environmental attitudes did not translate into actual purchase because consumers remained highly sensitive to price.

In the Indian context, research on consumer behaviour towards hydroponic vegetables is still limited. Kumar *et al.* (2022) ^[16] observed that only 42% of consumers in Bengaluru were aware of hydroponic farming, while also identifying high investment costs as a major challenge for industry expansion. Gole *et al.* (2020) ^[15] reported that even after a majority of consumers in Pune city expressed interest in purchasing hydroponic vegetables, many ultimately preferred conventionally grown produce due to lower prices comparatively, indicating a clear intention-behaviour gap. Related evidence from organic food sector in Ahmedabad city also demonstrated that health consciousness positively influences purchase intention (Jhaveri *et al.*, 2021) ^[12]. Additionally, Țălu (2024) ^[6] found that socio-demographic characteristics such as age and education level significantly affected the frequency of hydroponic vegetable consumption, while Chen *et al.* (2020) ^[2] showed that consumers rated hydroponically grown microgreens similarly to soil-grown alternatives, suggesting that sensory quality is generally not a major obstacle to consumer acceptance.

Overall, the studies done earlier indicates that consumers generally perceive hydroponic vegetables positively because of their health and environmental benefits, but the favourable attitude do not always lead to actual purchases, particularly where higher prices and limited availability were major

constraints. Although India represents one of the fastest-growing hydroponic markets globally, comprehensive evidence examining consumer awareness, perception, purchase intention, willingness to pay and purchasing constraints within a single analytical framework remains scarce. Addressing this research gap, the present study investigates these dimensions using primary survey data collected from 200 urban consumers in Hyderabad city of India.

2. Materials and Methods

The study adopted a descriptive, cross-sectional research design to examine consumers responses towards hydroponic vegetables. Primary data were collected from 200 urban consumers in Hyderabad city, Telangana, using a structured interview schedule administered through personal interviews between April and May 2026. Respondents were selected using a non-probability convenience sampling across fifteen retail outlets with 13-20 responses obtained from each location to ensure reasonable geographic spread within the city. Only the respondents who reported buying vegetables regularly were included in the survey.

The interview schedule consisted of five major sections. The first section collected information on the socio-economic characteristics of respondents, including gender, age, educational qualification, occupation, monthly household income and monthly expenditure on vegetables. The second section measured awareness using a five-point likert scale ranging from "Not Aware" to "Fully Aware" to know the level of awareness of respondents. These statements covered awareness regarding soilless cultivation, pesticide-free production, controlled-environment quality, premium positioning and availability of hydroponic vegetables in the local market. The third section assessed consumer perception through seven statements measured on a five-point agreement scale ranging from "Strongly Disagree" to "Strongly Agree". The statements examined perception related to health benefits, safety, taste, shelf life, environmental sustainability, sustainability for regular consumption and whether consumption of hydroponic vegetables represent a health-conscious lifestyle.

The fourth section examined factors influencing purchase intention using seven items rated on a five-point influence scale. The final section captured respondent's preference between hydroponic and conventionally grown vegetables when both were available at same price, preferred purchasing location and willingness to pay an additional premium for hydroponic vegetables. WTP was measured using four categories: no premium, 5-10%, 11-20% and more than 20%. Respondents were also asked to rank five possible constraints affecting their purchase of hydroponic vegetables.

Composite mean scores for the awareness and perception variables were computed and classified using class-interval method. Descriptive statistics and cross tabulation were employed to summaries the characteristics and responses of the respondents. Chi-square tests of independence were used to examine association between socio-demographic characteristics and awareness, perception and willingness to pay categories. The major constraints influencing purchase of hydroponic vegetables were analysed using Garrett's ranking technique. Individual ranks assigned to each respondent were first converted into percent positions using the formula:

$$\text{Percent Position} = 100(R_{ij} - 0.5) / N_j$$

where R_{ij} represents the rank assigned to the i^{th} constraint by the j^{th} respondent, while N_j denotes the total number of constraints ranked by the respondent. In the present study, five constraints were ranked by each respondent. The resulting percent positions were subsequently converted into Garrett scores using the standard conversion table provided by Garrett and Woodworth (1969). Finally, the mean Garrett score for each constraint was calculated across all 200 respondents, and the constraints were ranked according to their respective mean scores.

3. Results

3.1 Sample profile

The majority of the respondents were male (75.5%) and

relatively young. More than half of the respondents (55%) belonged to the 18-25 years age group, while another 36.5% were between 26-40 years of age. The educational profile of the respondents was comparatively high, with 51% being graduates and 41.5% holding postgraduate qualifications. Students constituted the largest occupational category, accounting for 41.5% of the sample, followed by respondents employed in the private sector (31.0%). Nearly half the sample (49.5%) reported a monthly household income below Rs. 50,000. Further 39.0% belonged to the Rs. 50,000-1,00,000 income group, whereas only 11.5% reported a monthly household income exceeding Rs. 1,00,000 and a third (33%) spent between Rs. 500 and Rs. 1,000 per month on vegetables. Overall, the sample represented a predominantly young, educated and relatively lower to middle income urban consumer group.

Table 1: Summary of the sample characteristics (n=200)

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	151	75.5
	Female	49	24.5
Age	18-25	110	55.0
	26-40	73	36.5
	41-55	10	5.0
	>56	7	3.5
Education	Higher Secondary	15	7.5
	Graduate	102	51.0
Occupation	Post Graduate	83	41.5
	Student	83	41.5
	Private sector	62	31.0
	Self-employed	37	18.5
Monthly household income	Other	18	9.0
	Below Rs. 50,000	99	49.5
	Rs. 50,000- Rs. 1,00,000	78	39.0
	Above Rs. 1,00,000	23	11.5
Monthly expenditure on vegetables	Below ₹500	20	10
	₹500 - ₹1000	66	33
	₹1000 - ₹2000	62	31
	Above ₹2000	52	26

3.2 Awareness of hydroponic vegetables

Overall consumer awareness was moderate (mean = 3.27 on a 1-5 scale). Awareness was relatively high concerning the fundamental characteristics of hydroponic cultivation. Awareness was highest for the basic fact that hydroponic vegetables are grown without soil (mean = 3.76). Awareness regarding cultivation under controlled environmental conditions was also comparatively high (mean = 3.59). However, awareness was comparatively lower with respect to the commercial aspects of hydroponic vegetables. Awareness was lower for their premium positioning (mean = 3.16), while awareness regarding their availability for purchase within Hyderabad was the lowest (mean = 2.56). This indicates that although consumers had a reasonable of the basic concept and production characteristics of hydroponic, their knowledge about where the products were available and their positioning in the market remained relatively limited. This pattern, strong conceptual awareness but weak market visibility awareness is consistent with Fahlevi *et al.* (2024) ^[8], who found that awareness functions

as a precondition for willingness to buy and with Kumar *et al.* (2022) ^[16], who similarly found that Indian consumer's awareness of hydroponics lagged well behind the technology's market growth.

3.3 Consumer perception

Consumer perception was favourable overall (mean = 3.62 on a 1-5 scale). Respondents mostly strongly associated hydroponic vegetables with environmental sustainability (mean = 3.82). Perception regarding safety and pesticide-free nature of hydroponic vegetables were also strongly positive (mean = 3.80). Respondents further considered hydroponic vegetables suitable for regular consumption (mean = 3.69). In contrast, taste was the least positively perceived attribute (mean = 3.29), with 62% of respondents rating taste as merely "Neutral". This taste perception gap is consistent with Saediman *et al.* (2024) ^[19], who found that Indonesian consumers favourable health and environmental perceptions did not extend equally to sensory attributes.

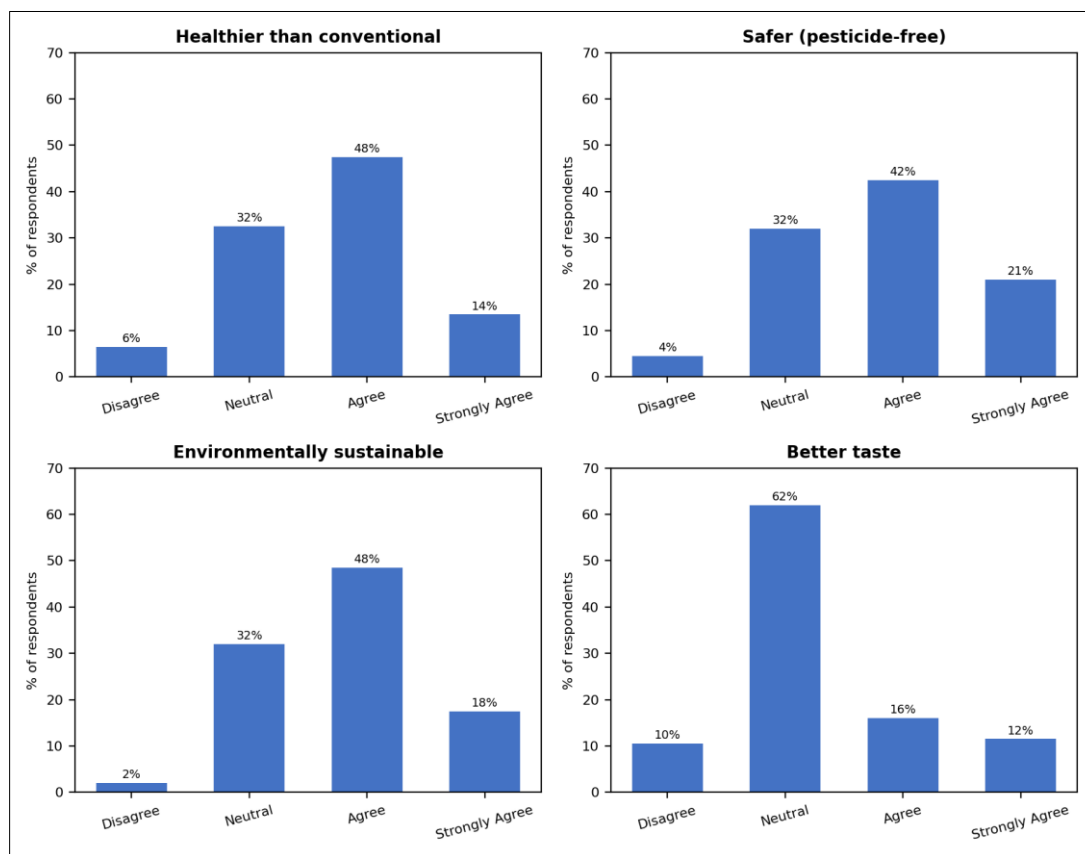


Fig 1: Distribution of consumer agreement with selected perception statements (n = 200)

3.4 Willingness to pay a premium price

Respondents were asked how much of a premium they would be willing to pay for hydroponic vegetables over conventionally grown vegetables. A majority (62%) were willing to pay a moderate premium of 5-10%, about one in four (26%) were not willing to pay any premium at all and only a small portion were willing to pay higher premiums, 11-20% premium price (7%) or more than 20% (5%). This shows positive willingness to pay moderate premium for hydroponic vegetables but their acceptance of higher prices remained relatively limited. The price-conservative distribution is broadly consistent with Balqiah *et al.* (2020) finding that WTP for hydroponic produce in Indonesia, another price-sensitive emerging market, tends to cluster at modest premium levels rather than extending broadly across higher price categories.

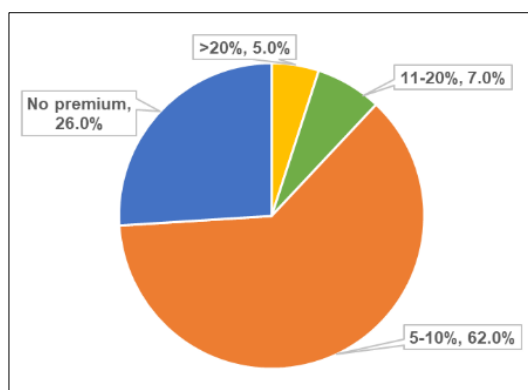


Fig 2: Distribution of respondents by willingness-to-pay premium band (n = 200)

3.5 Association between Household Income and Willingness to Pay

Table 2: Cross tabulation of monthly household income and WTP-premium

Monthly Household Income	0%	5-10%	11-20%	More than 20%	Total
Below ₹50,000	21	69	7	2	99
₹50,000-₹1,00,000	25	42	7	4	78
Above ₹1,00,000	6	13	0	4	23
Total	52	124	14	10	200

Table 3: Chi-square test of association between monthly household income and WTP-premium

Statistic	Value
Pearson chi-square	14.734
Degree of freedom	6
p-value	0.022
Decision ($\alpha = 0.05$)	Significant

The chi-square analysis revealed a statistically significant relationship between monthly household income and respondents' willingness to pay a premium for hydroponic vegetables (chi square = 14.734, df = 6, p = 0.022). Since the p-value was below the 0.05 significance level, the null hypothesis was rejected, indicating that household income had a significant association with willingness to pay a premium price. The cross tabulation further showed that respondents belonging to the highest income category, with a monthly household income above Rs. 1,00,000 were comparatively more willing to accept higher premium levels. Among those respondents, 17.4% indicated that they were

willing to pay more than 20% premium compared 2.0% to 5.1% of respondents in the two lower-income groups. In contrast, gender, age, educational qualification and occupation showed no statistically significant association with either awareness or perception (all $p > 0.05$).

3.6 Constraints to purchase

Garrett's ranking technique used to analyse and rank the five potential constraints faced by consumers while purchasing hydroponics revealed higher price as the most significant barrier to purchase (mean Garrett score = 60.3), followed by limited availability in local markets/stores (57.1), uncertainty about quality and nutritional value (49.6), difficulty in distinguishing hydroponic produce from organic or regular produce (45.1) and preference for traditionally grown or regular vegetables received the least mean Garrett score (37.9) and ranked last. The results indicates that the price and availability were the major constraints, whereas preference for regular vegetables was the least important constraint among the consumer. This suggests that consumers reluctance to purchase hydroponic vegetables was influenced more by economic, accessibility and product related concerns than by a strong preference for conventionally grown vegetables. This finding is consistent with Gole (2020) ^[15] and Saediman *et al.* (2024) ^[19] who reported that practical barriers such as price and availability could limit the conversion of favourable consumer perceptions into actual purchase decisions.

Table 4: Garrett ranking of constraints to purchasing hydroponic vegetables (n = 200)

Constraint	Mean Garrett Score	Rank
Higher price compared to conventional vegetables	60.3	I
Limited availability in local markets/stores	57.1	II
Uncertainty about quality and nutritional value	49.6	III
Difficulty in distinguishing hydroponic produce	45.1	IV
Preference for traditionally grown vegetables	37.9	V

4. Discussion

The aim of this study was to investigate consumers awareness, perception and purchase intention towards hydroponic vegetables in Hyderabad city.

The findings of this study indicate that consumer perception of hydroponic produce is dominated by health, safety and environmental sustainability beliefs rather than sensory attributes. This is broadly consistent with the study done by and Huang (2019) ^[11]. Although respondents demonstrated a positive willingness to pay for hydroponic vegetables, this willingness was concentrated mainly within lower premium categories. In the present study, only 5% of respondents were willing to pay more than 20% above the price of conventional vegetables, which represents a more conservative WTP pattern than that reported by D'Amico *et al.* (2024) ^[4], where more than one-third of Italian consumers accepted a premium of 20% or higher. One possible explanation is the relatively limited familiarity and market exposure to hydroponic vegetables in Hyderabad city.

The significant association between household income and willingness to pay a large premium, with high-income respondents (above Rs. 1,00,000) markedly more likely to

accept premiums of more than 20% which is consistent with Narine *et al.* (2014), who identified a positive relationship between income and WTP, and with Amalia *et al.* (2025) ^[1], who reported that income related factors played an important role than the demographic factors in shaping consumer purchase decisions. However, the present study showed no significant associations of gender, age, education, or occupation with awareness or perception. This differs to some extent from Tălu (2024) ^[6], who reported that demographic characteristics such as age and education significantly influenced the frequency of hydroponic vegetable consumption among European consumers. The difference suggests that, in the Hyderabad context, income may be more important than broader demographic characteristics when consumers evaluate higher price premiums and the acceptance.

The results from Garrett ranking of the purchase constraints provides further insights into the relatively moderate WTP levels observed. Higher price and limited availability were the two most significant barriers, while preference for conventional produce, which represented the main attitudinal barrier considered in the analysis, among five, was ranked last. A similar pattern was observed by Gole (2020) ^[15], who found that considerable purchase interest among consumers (71%) in Pune did not necessarily translate into actual purchasing behaviour because of price and accessibility barriers. Saediman *et al.* (2024) ^[19] likewise observed that Indonesian consumers had favourable health perceptions of hydroponic vegetables but considered price and availability to be important limitations. It is also consistent with Jiang *et al.* (2025) ^[13], who documented a "green consumption paradox" in which positive attitude hydroponic vegetables in post pandemic China did not consistently translate into purchasing behaviour due to price sensitivity. Similarly, Papilaya *et al.* (2022) ^[18] and Widodo *et al.* (2022) ^[20] both identified that price along with product quality as dominant drivers of actual purchase decisions in Indonesian consumers. Taken together, the findings of the current study are consistent, who found that purchase intention for hydroponic produce in Indonesia was strongly driven by health-related motivations rather than being determined solely by environmental concerns or demographic characteristics. Fahlevi *et al.* (2024) ^[8] similarly found that awareness alone was insufficient to generate willingness to buy without corresponding health and environmental perceptions. The findings from Hyderabad extend these observations to the Indian context. Although consumers displayed moderate awareness of hydroponic production and generally favourable perceptions, these positive views did not translate into broad acceptance of higher price premiums. This pattern is comparable with the intention-behaviour gap reported by Gole (2020) ^[15] and the findings from related Indian food categories reported by Jhaveri *et al.* (2021) ^[12].

From a managerial and policy perspective, these findings suggest that Indian hydroponic producers and retailers should adopt a differentiated approach rather than relying exclusively on premium positioning. Consumers with higher incomes and stronger perceptions of hydroponic vegetables may represent a suitable target segment for premium products supported by quality assurance, appropriate labelling and distribution through super markets and specialized retail outlets. This is particularly relevant because supermarkets

were identified as the preferred purchase channel by 66% of respondents. For the much broader consumer market, competitive pricing and improved retail visibility with greater product availability may be more effective than relying solely on health and sustainability based promotional messages. The relatively low awareness of local availability (mean = 2.56) and the price were leading constraints indicating that improving distribution and accessibility could play a substantial role in expanding consumer adoption.

5. Conclusion

This study analysed awareness, perception, willingness to pay and purchase constraints for hydroponic vegetables among 200 urban consumers in Hyderabad, India. Awareness among respondents was moderate and overall perception was favourable, particularly regarding the environmental sustainability and safety. A majority of consumers were willing to pay a moderate price premium of 5-10% for hydroponic produce, whereas only a small proportion were prepared to accept substantially higher premiums. Household income was the only socio-economic characteristic showing a statistically significant association with willingness to pay a premium. Consumers from higher income households were comparatively more willing to accept premiums exceeding 20%, whereas gender, age, education or occupation did not demonstrate significant associations with awareness and perception.

Higher price was identified as the most important barrier to purchase, followed by limited availability in local markets and stores. These findings indicate that consumer acceptance of hydroponic vegetables in an urban Indian market is shaped substantially by affordability, purchasing accessibility and market visibility. Competitive pricing and improved retail availability may be more effective in expanding the market in the short term than relying exclusively on awareness building and sustainability oriented promotional campaigns for greater adoption and to influence the consumer buying behaviour.

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