

Proceeding Paper

# Vertical Farming as a Sustainable Alternative for Agriculture: The Italian Consumer Point of View <sup>†</sup>

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**Abstract:** Despite innovative approaches to urban food production, scepticism towards vertical crops remains widespread, posing profitability risks for agricultural enterprises. To overcome these challenges and develop successful business models, identifying consumer acceptance barriers is crucial for engaging stakeholders, investors, and farmers in local food production. Introducing innovative food production methods, like vertical farming, is essential to gain public approval. However, recent technological advancements, such as genetically modified crops and artificial radiation, have been met with uncertainty, leaving overall consumer opinions about vertical farming uncertain. In this context, the propose of this paper is to analyse Italian consumers’ acceptance of vertical farming systems and products, aiming to understand the main drivers influencing their intentions to purchase. The research, conducted in Italy from April to May 2023, gathered qualitative and quantitative data through an anonymous online questionnaire completed by potential consumers. A total of 258 respondents were eligible for data analysis. The survey assessed participants’ knowledge, attitudes towards agriculture and food, and perceptions of vertical farming using Likert scale evaluations. Findings showed that, although a large proportion of respondents expressed interest in purchasing vertical farming products, concerns related to cost, authenticity, and environmental sustainability pose challenges. The evidences that emerged provides a series of indications to understand more in-depth consumer preferences and useful suggestions for companies that need to expand the vertical farming products market.

**Keywords:** vertical farming; consumer perception; urban agriculture; survey analysis

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## 1. Introduction

The enormous growth in the world’s population over the past century has been accompanied by an exponential increase in the demand for food, which has led, in turn, to the exploitation of 80% of the global arable land with disastrous consequences for the natural environment [1]. This trend is not likely to stop in the short term, and it is estimated that by 2050 there will be 9 billion individuals on earth [2]. For this reason, it will be necessary to exploit more and more arable land and intensify agricultural efforts, with likely repercussions at the global level [3]. One of the possible solutions to meet this growing demand is Vertical Farming, a technique that consists of large-scale indoor food production that allows for the rapid growth of crops, placed on overlapping layers, employing artificial lighting systems, climate control, automation, and hydroponic, aquaponic, and aeroponic growing techniques to provide plants with ideal growing conditions [4]. This approach, therefore, allows more plants to be grown year-round in less space than traditional soil-based agriculture, making production more efficient by cutting down on water and nutrient wastage, fertilizer and pesticide use, and production losses due to

weather and seasonal influences [3,5,6]. Anyhow, vertical agriculture is constantly evolving, and several challenges need to be addressed to fully express their potential in terms of environmental, economic, and social sustainability [7,8]. However, success in solving these problems does not guarantee the spread of vertical farming in the mass market as it could be subject to consumer mistrust.

To this end, the purpose of this study is to explore the main causes driving the acceptance of VF systems and their products, as well as the purchase intention of consumers. Recent technological innovations in agriculture have often met with skepticism and distrust. This is also the case for vertical farming [9]. As a result, the general opinion of consumers on vertical farming and its products is still uncertain. Distrust of this new technology could threaten farm profitability and increase the risk of bankruptcy. Identifying barriers to consumer acceptance of vertical farming could provide an essential foundation for overcoming existing challenges and developing a successful business model for local food production by engaging stakeholders, investors, and farmers.

## 2. Materials and Methods

The research was conducted in Italy between April and May 2023, consisting of a collection of data through the completion of an anonymous online questionnaire by prospective consumers. The final total sampling is 258 respondents. The survey design has been obtained following some previous works [10–12]. The survey begins with a question about previous knowledge of vertical farming. Then, the questionnaire tests the respondents' general knowledge and attitudes toward agriculture and food through a five-point Likert scale. In the next section, the respondents' level of liking toward several characteristics of vertical agriculture is analyzed. At this point, the "climax" question is introduced by which the respondent is asked whether they are interested in purchasing vertically grown products. Three possible answers ("Yes", "No", "Don't know") are provided for this question, based on which respondents move to three different sections: "Yes" respondents are asked to rate a series of statements about their perceptions of VF and to choose from a list the type of agricultural products they like best. "No" and "Don't Know" respondents are asked to rate a few possible reasons why they are uncertain or unwilling to purchase VF products. The questionnaire concludes with socio-demographic questions about the respondents.

## 3. Results

The sample consists of 258 consumers from Italy. The percentage distribution of different socio-demographic profiles related to gender, age, and education can be seen in Table 1. The gender distribution is almost homogeneous, with a slight majority of female participation. As far as age is concerned, there appear to be proportionately more people in their 20 s and 30 s, probably due to the university context in which the survey was conducted, followed by the over-50 s. Half of the participants hold a bachelor's degree, while 12% hold a postgraduate or doctoral degree.

**Table 1.** Sample characteristics.

|           |        | Sample | Sample in % |
|-----------|--------|--------|-------------|
| Gender    | Female | 135    | 52.33       |
|           | Male   | 123    | 47.67       |
| Age       | <20    | 7      | 2.71%       |
|           | 20–30  | 117    | 45.35%      |
|           | 31–40  | 26     | 10.08%      |
|           | 41–50  | 20     | 7.75%       |
|           | >50    | 88     | 34.11%      |
| Education | Other  | 2      | 0.78%       |

|                              |     |        |
|------------------------------|-----|--------|
| Elementary school            | 2   | 0.78%  |
| Secondary school             | 10  | 3.88%  |
| High school                  | 84  | 32.56% |
| Bachelor’s degree            | 129 | 50.00% |
| Postgraduate master’s degree | 31  | 12.02% |

The data obtained indicate that 59.3% of the respondents had prior knowledge about vertical farming, while 40.7% of them were unfamiliar with the topic.

A large majority of the participants (89%), consider sustainability in food production an important aspect. The same attitude is found regarding the absence of pesticides to protect the environment (78%) and the fact that there is a high waste of water in conventional agriculture (68%). This is in line with the perception of the environmental unsustainability of conventional agriculture shared by nearly 54% of people.

The next section consists of seven statements describing some characteristics of vertical farming for which respondents were asked to rate their agreement (Table 2). The feature that has been most successful is the reduced environmental impact of this technology, with an average score of 4.29, followed by the freshness of food sold (M = 4.03), production capacity (M = 3.98), and controlled growing conditions (M = 3.93). As might be expected, the aspects least liked by respondents are high prices, for which 64.7% of respondents rated it negatively, and the high energy use required by this production system, which received an average score of 2.47. The statement on the use of artificial intelligence systems and robotic automation received positive opinions overall, with an average response of 3.47, but in this case many individuals expressed a neutral opinion.

**Table 2.** Descriptive statistics of general approval toward features of vertical farming.

| Statements  | (1)         | (2)          | (3)         | (4)         | (5)          | M    |
|---|-------------|--------------|-------------|-------------|--------------|------|
| Growing fruits and vegetables in vertical farming can help reduce carbon emissions                        | 6<br>2.3%   | 10<br>3.9%   | 21<br>8.1%  | 87<br>33.7% | 134<br>51.9% | 4.29 |
| Energy requirements of vertical farming systems are often high due to heating, cooling and lighting needs | 45<br>17.4% | 114<br>44.2% | 48<br>18.6% | 36<br>14.0% | 15<br>5.8%   | 2.47 |
| Supermarkets are stocked daily with freshly harvested fruits and vegetables                               | 14<br>5.4%  | 27<br>10.5%  | 17<br>6.6%  | 79<br>30.6% | 121<br>46.9% | 4.03 |
| Indoor vertical farming can produce up to five times more than traditional outdoor farming methods        | 11<br>4.3%  | 24<br>9.3%   | 31<br>12.0% | 84<br>32.6% | 108<br>41.9% | 3.98 |
| Fruits and vegetables produced through vertical farming systems are likely to be sold at high prices      | 54<br>20.9% | 113<br>43.8% | 36<br>14.0% | 46<br>17.8% | 9<br>3.5%    | 2.39 |
| Vertical farming often relies on automation, robotics and advanced artificial intelligence systems        | 14<br>5.4%  | 51<br>19.8%  | 46<br>17.8% | 94<br>36.4% | 53<br>20.5%  | 3.47 |
| Plants grow inside buildings under fully controlled conditions  | 8<br>3.1%   | 27<br>10.5%  | 36<br>14.0% | 90<br>34.9% | 97<br>37.6%  | 3.93 |

**Note:** (1) I do not like it at all, (2) I do not like it much, (3) It is indifferent to me, (4) I like it enough, (5) I like it a lot; (M) Average.

The main question of the survey, on the attitude toward purchasing products created by vertical farming techniques, included three different responses (*Yes*, *No*, and *Don't know*) leading to three different ramifications of the questionnaire. The three groups consisted of n = 154 people for the *Yes* answer, n = 76 for the *Don't know* answer, and n = 28 for the *No* answer, respectively.

The first group accounted for 60% of the entire sample. Respondents then had to rate three statements through a five-level Likert scale (Table 3). Results show that price is a strong discriminate for prospective buyers, who are generally unwilling to spend more on vertically grown produce (M = 2.69). In addition, the statement “Vertically grown produce is healthier than conventionally grown produce” has an average of 3.12 with more

than 50% of the responses “Neither agree nor disagree” underscoring the fact that vegetables grown with this technology, at least for the time being, are not perceived to be healthier and superior in quality to classic ones; this could therefore influence people’s refusal to pay more for them. The third statement, on vertical farming as a possible evolution of traditional agriculture, collected average positive responses (M = 3.55); again, however, many people would seem to be undecided about this (42.2% of responses). The last question in this section of the questionnaire required respondents to make a choice in terms of preference among several possible types of food production. Vertical farming products are far from being the most popular choice, getting only 8% of responses in favor. The main option is local and organic products chosen by 48% of people, while a large segment of participants do not have a specific preference (17%).

**Table 3.** Descriptive statistics of the comparison between VF and traditional products.

| Statements   | (1)       | (2)         | (3)         | (4)         | (5)         | M    |
|--|-----------|-------------|-------------|-------------|-------------|------|
| I would be willing to pay more for vertically grown produce than conventionally grown produce. | 20<br>13% | 48<br>31.2% | 51<br>33.1% | 30<br>19.5% | 5<br>3.2%   | 2.69 |
| Vertically grown produce is healthier than conventionally grown produce                        | 6<br>3.9% | 25<br>16.2% | 79<br>51.3% | 32<br>20.8% | 12<br>7.8%  | 3.12 |
| I believe Vertical Farming is the future of agriculture  | 3<br>1.9% | 7<br>4.5%   | 65<br>42.2% | 61<br>39.6% | 18<br>11.7% | 3.55 |

**Note:** (1) Completely disagree, (2) Disagree, (3) Neither agree nor disagree, (4) Agree, (5) Completely agree; (M) Average.

The second most populous group of interviewed consisted of the *Don’t Know* respondents to the question “would you buy vertically grown products”, representing 29% of the total sample. In this case, the questionnaire proposed a range of possible reasons to explain uncertainty about buying VF products (Table 4). Studying the response averages, the cause that most reflects the perplexity of this group of people is the lack of knowledge about this cultivation technique (M = 3.75). Responses to the last question in this section, which asked respondents to express an opinion on the possible future evolution of vertical farming as the main cultivation technique, again show strong doubt and indecision with a clear majority of people choosing “Neither agree nor disagree” as their answer (n = 42 out of a total of 76 responses).

**Table 4.** Descriptive statistics of the causes of uncertainty toward the purchase of VF products.

| Statements  | (1)      | (2)       | (3)       | (4)       | (5)       | M    |
|---|----------|-----------|-----------|-----------|-----------|------|
| I have doubts about the quality of the products               | 6<br>8%  | 17<br>22% | 33<br>43% | 18<br>24% | 2<br>3%   | 2.91 |
| High prices   | 8<br>11% | 14<br>18% | 24<br>32% | 27<br>36% | 3<br>4%   | 3.04 |
| I do not consider it a sustainable project                    | 9<br>12% | 21<br>28% | 38<br>50% | 5<br>7%   | 3<br>4%   | 2.63 |
| I am skeptical about this technology                          | 7<br>9%  | 14<br>18% | 42<br>55% | 12<br>16% | 1<br>1%   | 2.82 |
| I perceive the production as too artificial                   | 6<br>8%  | 15<br>20% | 32<br>42% | 21<br>28% | 2<br>3%   | 2.97 |
| I prefer food grown by the traditional method                 | 5<br>7%  | 10<br>13% | 31<br>41% | 20<br>26% | 10<br>13% | 3.26 |
| I do not feel that I have enough information to make a choice | 7<br>9%  | 2<br>3%   | 18<br>24% | 25<br>33% | 24<br>32% | 3.75 |

**Note:** (1) Completely disagree, (2) Disagree, (3) Neither agree nor disagree, (4) Agree, (5) Completely agree; (M) Average.

Finally, the last group of respondents consists of the *No* respondents represents 11% of the sample. The survey, in this case, included a range of possible reasons to explain the aversion to buying vertically grown produce (Table 5). The main and most shared cause deterring this group of possible consumers from purchasing is the perception of vertical farming products as too artificial ( $M = 3.54$ ). Followed by higher mean are the statements “I prefer conventionally grown foods” with  $M = 3.46$  and “I have doubts about the quality of the products” with a mean of 3.39. Again, the last question in the section asked respondents to rate vertical farming as a possible future of agriculture, obtaining a generally negative average response of 2.18.

**Table 5.** Descriptive statistics of the causes of rejection toward the purchase of VF products.

| Statements                                      | (1)      | (2)      | (3)       | (4)       | (5)      | M    |
|---|----------|----------|-----------|-----------|----------|------|
| I have doubts about the quality of the products | 3<br>11% | 3<br>11% | 7<br>25%  | 10<br>36% | 5<br>18% | 3.39 |
| High prices                                     | 6<br>21% | 4<br>14% | 6<br>21%  | 5<br>18%  | 7<br>25% | 3.11 |
| I do not consider it a sustainable project      | 4<br>14% | 3<br>11% | 10<br>36% | 10<br>36% | 1<br>4%  | 3.04 |
| I am skeptical about this technology            | 3<br>11% | 4<br>14% | 12<br>43% | 4<br>14%  | 5<br>18% | 3.14 |
| I perceive the production as too artificial     | 3<br>11% | 1<br>4%  | 8<br>29%  | 10<br>36% | 6<br>21% | 3.54 |
| I prefer food grown by the traditional method   | 3<br>11% | 3<br>11% | 6<br>21%  | 10<br>36% | 6<br>21% | 3.46 |
| I am not interested in these products           | 3<br>11% | 5<br>18% | 10<br>36% | 7<br>25%  | 3<br>11% | 3.07 |

**Note:** (1) Completely disagree, (2) Disagree, (3) Neither agree nor disagree, (4) Agree, (5) Completely agree; (M) Average.

#### 4. Discussion and Conclusions

The objective of the present study was to analyze Italian consumers' perceptions of vertical farming techniques by examining their knowledge about them, behavioral attitudes and purchasing preferences, with the aim of providing useful information and insights to companies operating in the country.

Italian consumers are showing a growing awareness of the negative impact of conventional agriculture on the environment and the intensive use of water and pesticides, believing that sustainability in food production is important. In addition, survey participants, appreciated several benefits associated with vertical farming, such as reduced CO<sub>2</sub> emissions, freshness of vegetables supplying supermarkets due to reduced supply chains and increased production capacity. Another aspect relevant to consumers is food safety, and vertical farming offers optimal control of growing conditions, reducing the risk of contamination and plant diseases.

The results of this study are in line with previous studies found in the literature [10–13], showing that Italian consumers have similar preference and concerns around these technologies. Although a significant portion of the sample is interested in purchasing vertically grown products (60% of the total sample), there is still a considerable percentage of people who have shown no interest or are uncertain. A large proportion of the respondents have no knowledge of the topic or do not possess enough notions to have a definite opinion about it. The perception of cost and genuineness seems to influence the propensity to purchase, as potential buyers are not willing to pay a higher price for vertical products and do not perceive a clear superiority in terms of quality over traditional products. Although significantly more people are predisposed than those who gave negative or uncertain responses, data analysis shows that only 8% of respondents listed VF vegetables as their main purchase preference. The most popular choice among the proposed food

options is local and organic produce, elected by 48% of individuals. A significant percentage of participants (17%), however, did not express a specific preference.

These results suggest that to capture a wider market share, it may be necessary for companies in the industry to focus on improving the perception of quality-price in possible consumers. In addition, the fact that a significant percentage of respondents did not express a specific preference could indicate a potential opportunity to attract new buyers through innovative and attractive product offerings. For the group of respondents who are undecided about buying vertically grown products, the main concerns are food quality, high prices, and lack of knowledge on the subject. This indicates the need for more information and awareness about the benefits of vertical farming to win over this category of customers. On the other hand, the group that responded negatively to the survey expressed broader concerns. In addition to product quality and high prices, they cited the unsustainability of the project, skepticism toward the technology used, and the perceived artificiality of the food. These critical points could be addressed through education about the sustainable practices of vertical farming, transparency regarding the technologies used, and a stronger and more widespread information campaign that would help dispel doubts and encourage a more favorable attitude toward this innovative technique.

What emerges from the survey is therefore the need to make this cultivation technique known, transmitting the values and advantages that underlie vertical farming. In a country with a strong and deeply rooted culinary culture like Italy, it is certainly more complicated to get consumers to accept new food technologies if they are seen as discordant with what the traditions are, but rescuing in this challenge would make local players very competitive on the market.

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