Cultivating Change: The Role of Consumer Innovativeness and Psychological Factors on the Attitudes Towards Indoor Vertical Farmed Greens

Lisa Marie Eßmann

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Abstract

Title: Cultivating Change: The Role of Consumer Innovativeness and Psychological Factors on the Attitudes Towards Indoor Vertical Farmed Greens

Author: Lisa Marie Eßmann

With the challenges of rapid urbanization, world population growth, and the climate crisis, the world is facing a dilemma. It is necessary to address these challenges through technological innovations, such as Vertical Farming (VF). However, in order to do that it needs the consumer's willingness to change their consumption behavior and a general positive mindset towards those innovations. A mixed-methods analysis was conducted to study the attitudes and behaviors towards VF products within this thesis.

The study examined whether a consumer's degree of innovativeness has a significant effect on the attitudes towards buying vertically farmed greens. The results showed positive results. Therefore, it can be concluded that people with a higher likelihood to adapt innovations are strongly shaping the VF market. Surprisingly, the psychological factor of subjective knowledge about VF was not identified as a significant factor. Moreover, the findings demonstrate that attitudes towards vertically farmed greens are mainly affected by product characteristics such as freshness, healthiness, and quality. Another significant factor revealed by this study is sustainable consumption in the context of VF. As the results showed a general willingness to pay a price premium for vertically farmed greens, VF companies could exploit the premium price segment.

Overall, the examination of the urban agriculture sector gives implications for marketers and researchers who aim to enter or further investigate the VF market. It suggests treating VF as an innovation with the need for education, which has the potential to gain a buyership within the German market.

Keywords: Vertical Farming | Urban Agriculture | Technological Innovation | Sustainable Consumption | Attitudes

Sumário

Título: Cultivar a mudança: O Papel da Inovação do Consumidor e dos Factores Psicológicos nas Atitudes em Relação às Verduras Cultivadas Verticalmente no Interior

Autor: Lisa Marie Eßmann

Com os desafios da rápida urbanização, o crescimento da população mundial e a crise climática, o mundo está a enfrentar um dilema. É necessário enfrentar estes desafios através de inovações tecnológicas, como a Agricultura Vertical (AV). No entanto, para o fazer, é necessária a vontade do consumidor de mudar o seu comportamento de consumo e uma mentalidade geral positiva em relação a essas inovações. Foi efectuada uma análise de métodos mistos.

O estudo examinou se o grau de inovação de um consumidor tem um efeito significativo nas atitudes em relação à compra de produtos hortícolas cultivados verticalmente. Os resultados foram positivos. Surpreendentemente, o fator psicológico do conhecimento subjetivo sobre as FV não foi identificado como um fator significativo. Além disso, os resultados demonstram que as atitudes em relação aos produtos hortícolas cultivados verticalmente são principalmente afectadas pelas características do produto, como a frescura, a salubridade e a qualidade. Outro fator significativo revelado por este estudo é o consumo sustentável no contexto das AV. Uma vez que os resultados revelaram uma vontade geral de pagar um preço mais elevado pelas verduras de cultura vertical, as empresas de AV podem explorar o segmento de preços mais elevados.

De um modo geral, a análise do sector da agricultura urbana traz implicações para os comerciantes e investigadores que pretendam entrar no mercado das AV ou investigá-lo mais a fundo. Sugere que se trate a AV como uma inovação com necessidade de educação, que tem o potencial de conquistar um comprador no mercado alemão.

Palavras-chave: Agricultura Vertical | Agricultura Urbana | Inovação Tecnológica | Consumo Sustentável | Atitudes

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This thesis marks the end of my academic career. Within the past one and a half years, my studies at the Católica Lisbon helped me develop a fundamental knowledge within and around the field of Strategic Marketing. Moreover, I was able to meet a lot of inspiring people, make new friends, and widen my business network. All of this enabled my personal growth within the last months, and I will always be thankful for that.

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Moreover, I would like to thank my Professor, Miguel Rita. With his focus on the food industry and product innovation, he inspired me to choose a topic within the food tech business and sparked me with his deep knowledge of the industry. Additionally, he motivated, mentored, and guided me throughout the whole journey, showing a good mixture of external input but also leaving decisions to myself.

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List of Abbreviations

&	And
AV	Agricultura Vertical
df	Degrees of Freedom
p	p-value
H1	Hypothesis 1 (2-6 respectively)
M	Sample Mean
N	Total Number of Cases
RQ1	Research Question 1 (2-6 respectively)
SD	Standard Deviation
SE	Standard Error
TAM	Technology Acceptance Model
TPB	Theory of Planned Behavior
VF	Vertical Farming

1 Introduction

"How might we feed 1,7 billion additional people on our planet in 2050, with the same limited resources we have today?"

(Susteyn, 2023)

Due to world population growth, arable land per person is expected to decrease to one-third of its 1970 level by 2050 what puts a lot of pressure on our current food system (United Nations Food and Agriculture Organization, 2009). Therefore, drastic changes in eating habits and new approaches towards traditional agriculture are needed to meet the food needs of the future sustainably (Dutta et al., 2023). On top of that, we are facing challenges such as rapid urbanization, climate change, shrinking arable land, changing consumer diets, and the urgent need to conserve resources. All these factors are driving innovation in the urban food production sector. In fact, 80% of the world's population is expected to live in cities or urban areas by 2050 (Mishra, 2023; Specht et al., 2019).

A solution tackling these problems could be indoor VF. Within these cultivation systems, productivity can be significantly increased, and the environmental footprint reduced (Benke & Tomkins, 2018). Vertical farms represent a change in modern agriculture, as they allow the growth of a large range of fresh, high-quality food within urban areas (Despommier, 2009). Moreover, there are a lot of ongoing energy innovations as well as the development of AI solutions and automations within VF industry right now. Therefore, these large-scale vertical farms have the potential to become more scalable, sustainable, and economical within the next years.

VF might be a promising approach to address many environmental, social, and economic issues around the future food supply. However, it also requires a fundamental shift in the way we know and do agriculture. People are still skeptical about this kind of high-tech innovation, even though there is a growing demand for local, functional, and sustainable food (Despommier, 2013; Kozai et al., 2020; Specht et al., 2019; Specht, Weith, et al., 2016a). Based on naturally poor growing conditions, the fast acceptance of new technologies, and the high market demand, the expansion of the VF industry mainly focuses on regions as Southeast Asia, North America, and some European countries. However, German VF companies are experiencing failures to successfully enter the market. In general, German agriculture can be described as competitive on the global level.

Nevertheless, this balance might be disrupted by the development of new technologies and population growth in the future. This was underlined by the German start-up *Infarm*, who recently failed to successfully enter the German market. The company stated that high energy costs and the fact that the demand is higher in other regions, such as North America, are the main reasons (JustFood, 2023). However, the reason for the lack of demand within Germany remains unclear. How do consumers perceive vertically farmed products in the German market? Are there any misperceptions regarding VF greens that could potentially be addressed? What kind of customer is interested in the purchase of vertically farmed products?

Several literatures aimed to study the VF market and its surrounding constructs. A bunch of literature focused on the comparison between different VF systems and shading light into the different states of technological innovation within the cultivation systems (Benke & Tomkins, 2018; Khalil & Wahhab, 2020; Maurya et al., 2023; Sanyé-Mengual et al., 2015). Others focused on examining sustainability issues around VF and explored the competitive economic prospect of vertical farming (Martin & Molin, 2019; Moghimi & Asiabanpour, 2023). Moreover, there has been literature on the investigation of the acceptance and perceptions of various VF systems (Jürkenbeck et al., 2019; Perambalam et al., 2021; Specht, Siebert, et al., 2016; Specht, Weith, et al., 2016). However, the literature review revealed a gap in the existing literature regarding the VF situation in the German market. Therefore, this research aims to address this gap by studying consumer perceptions and underlying motives of VF greens grown in large-scale farms. Moreover, it provides an overview of current market dynamics, potential barriers, and the role of sustainability in forming perceptions of vertically farmed greens. The purpose of this thesis is to address the following central research question:

- **Main RQ:** "What is the influence of consumer innovativeness and further psychological factors on their attitudes towards buying indoor vertically farmed greens?".

To build up an analysis around this central research question, it was divided into the following six sub-questions:

- **RQ1:** Are consumers who feel closer to food tech innovation more likely to buy vertically farmed greens?

- **RQ2:** Are people who already have subjective knowledge about VF more likely to buy vertically farmed greens?
- **RQ3:** How do different attitudes towards vertically farmed greens affect the attitude towards buying such products?
- **RQ4:** Do people with a general interest in sustainable food production perceive vertically farmed greens as more sustainable?
- **RQ5:** Are people more likely to buy vertically farmed greens if they perceive them as sustainable?
- **RQ6:** Do people who are generally willing to pay a premium for vertically farmed greens have a positive attitude towards buying them?

The six research questions were investigated by making use of a mixed-methods analysis. The foundation for the study was exploratory research, conducting semi-structured expert interviews and semi-structured consumer interviews. This initial research provided an overview of the current market situation and market perceptions within relevant target groups. An online survey was conducted to measure the different consumer interests as well as perceptions and attitudes towards vertically farmed greens. This research not only enriches the current literature but also lays a solid foundation for companies aiming to enter the German market.

The thesis follows a classical structure of empirical papers. It starts with an introduction that has already examined the topic's relevance, problem statement, and research questions. Afterwards, the literature review in Chapter 2 creates a general understanding of relevant concepts related to VF. Moreover, the review examines the industry's growth in the past years, analyzes its major benefits and challenges, and derives the hypotheses. Chapter 3 presents a theoretical framework, refining relevant constructs and relationships based on the literature review and exploratory research. Based on that, Chapter 4 describes the execution of all studies to answer the research questions. Subsequently, Chapter 5 discusses the main findings in line with the literature findings, delivers managerial and theoretical implications, points out limitations, presents potential implications for future research, and summarizes the findings.

2 Literature Review

2.1 Definition Urban Agriculture

The term urban agriculture describes the general need to bring greenery and sustainability back into cities. It covers a wide range of agricultural activities, usually located within or on top of a town or a city (Thebo et al., 2014). Within these agricultural systems, many of food and non-food products get cultivated, processed, and distributed (Orsini, 2013). Moreover, urban agriculture products and services serve the needs of urban populations, which makes it an innovative approach to urban community development (Mougeot, 2000). Overall, urban agriculture encompasses various forms of agricultural activities, with VF being one of them.

2.2 Definition Vertical Farming

VF is an innovative agricultural technique that cultivates large-scale food production in high-rise buildings. It allows the cultivation of various plants in a controlled environment, making use of the latest greenhouse technologies and automation (Banerjee & Adenaeuer, 2014; Despommier, 2011). Therefore, it is as “a system of commercial farming whereby plants, animals, fungi and other life forms are cultivated for food, fuel, fiber or other products or services by artificially stacking them vertically above each other” (Banerjee & Adenaeuer, 2014).

Moreover, VF does not only encompass indoor vertical farming systems but also rooftop farms and vertical greens walls, which can be described as innovative small-scale approaches towards urban farming and a local food production (Khalil & Wahhab, 2020). On the other hand, large-scale vertical farms present a potential solution to address the issue of food scarcity as they are promising alternatives to conventional farming methods. These cultivations occur in multi-story buildings or greenhouses that cultivate various fish and crop species. Many cities have implemented this model in old buildings such as warehouses. In that way, these buildings get repurposed for agricultural activities (Al-Kodmany, 2018; Despommier, 2013).

These kinds of large-scale vertical farms optimize space utilization and growing conditions. Typical advantages of vertical farms are reduced resource consumption (e.g., water savings of up to 90%), automated air temperature and humidity control systems, and artificial LED lighting. In that way, indoor farming enables year-round harvesting and cultivation of diverse plants with systems that are programmed to meet the market demand. Moreover, there is no need for fertilizers, herbicides, or pesticides. The crops are protected from viruses, pests, and harsh weather conditions, which are becoming more frequent due to the negative effects of climate change (Benke & Tomkins, 2018; Despommier, 2011; Pavithra & Royston, 2018). All these factors lead to an annual productivity per unit area that is more than 100 times higher than the one from conventional outdoor farming (Kozai et al., 2020). Ultimately, this form of urban agriculture may only partially replace conventional farms. Still, both models must complement each other to meet the growing food demands of the future (Grant, 2022).

2.3 The Rise of Vertical Farms

In recent decades, conventional, horizontal, outdoor agriculture has moved away from urban centers. The main reasons are rapid urbanization and other economic factors (Khalil & Wahhab, 2020). However, the excessive use of the soil, as well as the use of various chemicals, led to a rapid decrease in soil quality.

At this point, VF occurs. Vertical farms or vertical gardens have been known since the 20th century. They can be traced back to the rise of urban agriculture with its potential to address community food security issues (Al-Chalabi, 2015; Khalil & Wahhab, 2020). In 1999, Dickson Despommier, an American ecologist and professor of public health, introduced the original version of VF. He highlighted the relevance of vertical farms as a sustainable, futuristic solution to address urban challenges (Besthorn, 2013). His approach describes an urban, indoor, high-rise, climate-controlled factory that is powered by renewable energy (Despommier, 2011; Pavithra & Royston, 2018). Moreover, Despommier suggested locating the farms within the centers of large cities (Benke & Tomkins, 2018). Until today, this idea aligns with the strategic positioning of the most successful vertical farms worldwide.

Since then, the VF industry has been experiencing rapid growth. Europe and North America emerged as pioneers in the sustainable food production sector. Also, densely populated Asian cities, such as Hong Kong, Tokyo, and Kuala Lumpur, are strengthening their positioning in the urban agriculture market (Kalantari et al., 2017). In addition, interviews with industry experts revealed insights into the current market situation (Appendix 3). An industry expert working for a European VF company pointed out that the Middle East and Scandinavia are attractive European markets for VF because of their naturally poor growing conditions. She also highlighted that Germany lacks market attractiveness (Appendix 3.1). These findings reveal that Germany is currently facing challenges regarding the integration of large-scale vertical farms, which makes it an interesting market to study. Moreover, a lot of technological research and development is taking place within the VF sector. Several new cultivation techniques are emerging in the market with the goal to make the systems even more efficient and environmentally friendly.

2.4 Vertical Farming Systems and Crop Cultivation

Different VF systems and techniques, such as aquaponics, hydroponics, and aeroponics, are emerging in the market, all focusing on utilizing horizontal space and resources most efficiently. For a more detailed explanation of the different systems and their advantages, see *Appendix 1*.

Within these different systems, various crops get cultivated, reflecting adaptability and versatility. In general, few characteristics must be met for the commercial production of plants in indoor vertical farms. One requirement is a maximum plant height of 30 cm. Another requirement is the cultivation of fast-growing plants that grow well under high planting densities and artificial conditions. In addition, around 85% of the agricultural mass should be able to be used for direct sales. Therefore, companies predominantly focus on leafy greens like lettuce, chard, cabbage, rocket, kale and herbs such as basil, mint, chives, and parsley (Grant, 2022).

In comparison, crops such as rice, tomatoes, and cucumbers have a low yield potential as they require much more energy to grow and take up way more space to produce relatively little output (Moghimi, n.d.; Moghimi & Asiabanpour, 2023, Plant factory). As VF technology has advanced, some companies have expanded into growing other crops like strawberries and microgreens. However, leafy greens remain one of the most profitable ones. Therefore, VF start-ups mainly focus on the cultivation of leafy greens. The interview with industry expert Stefano Augstburger, CEO of a VF company in Switzerland, revealed that berries and other vegetables need much more technological development to be profitable in the future (Appendix 3.2). Therefore, this research focuses on examining consumer behavior towards leafy greens.

2.5 Challenges of the Vertical Farming Industry

As stated in the first chapter, VF offers several benefits and advantages. On the other hand, it also faces several challenges and concerns.

One major challenge is that indoor VF is still significantly more expensive than comparable traditional methods (Moghimi & Asiabanpour, 2023). The most challenging part of the costs are the high set-up costs. Not only the price of the needed high-tech equipment and raw materials, but also the initial investment in the system itself is quite high (Benke & Tomkins, 2018; Maurya et al., 2023; Appendix 3.2). In particular, the scale-up process adds cost and complexity. However, in the end, it is necessary to lower the unit price for the end user. This major challenge was underlined in the expert interview with Stefano Augstburger. He mentioned rising interest rates for capital-intensive businesses and the fact that technological improvements in the industry depend strongly on overcoming this financial barrier (Appendix 3.2).

To tackle the problem of high energy costs there are several developments in technology taking place, such as energy-efficient LED lighting. However, there are high energy costs now which account for almost 40% of total production costs. This challenges not only the energy footprint but also the profitability of VF businesses (Benke & Tomkins, 2018; Perambalam et al., 2021). Industry experts validated the literature findings. They indicated that high energy costs are currently one of the biggest challenges, especially in Germany, and have already led to the withdrawal of some companies from the German market (Appendix 3).

Additional challenges are high labor costs due to the requirement for skilled professionals. Furthermore, indoor VF will result in job losses because of technological progress (Maurya et al., 2023).

Another primary concern within the VF industry is the environmental impact of these indoor cultivation systems. The environmental performance of a vertical hydroponic system in Sweden has shown that several changes and technological developments need to happen in order to drastically improve the sustainability of VF systems (Martin & Molin, 2019). According to industry expert Stefano Augstburger, the revolutionizing of the market does not allow a strong focus on sustainability right now, even though the general idea behind VF aligns with a sustainable approach (Appendix 3.2).

3 Theoretical Framework

The main research question posed in this thesis aimed to evaluate the role of several personal and psychological factors on the attitudes towards buying vertically farmed greens. Therefore, this thesis made use of constructs based on the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB) (Davis, 1989; Ajzen, 1985).

The TAM model aims to evaluate to which extent consumers value innovative technologies. It identifies the factors that influence the consumer's acceptance of technologies, how they perceive them, and what leads to their behavioral intentions in the end (Davis, 1989). Complementary, the TPB model states that a person's behavior is influenced by their attitudes, subjective norms, and perceived behavioral control. This framework implies that people are more likely to engage in a particular behavior if they have a positive attitude towards it. Both models are based on the Theory of Reasoned Action (TRA). The TRA focuses on predicting behavior and has been used in many studies investigating diverse food issues (Ajzen, 1985).

A study on the theory of buyer behavior revealed that consumers are not always rational decision-makers and that their purchase behavior is highly influenced by various psychological and social factors, such as subjective knowledge (Haines et al., 1970). Therefore, the investigation of personal factors like food technology innovativeness, as well as psychological factors such as subjective knowledge and different attitudes towards vertically farmed greens, were crucial. Other factors included in the TAM and TPB, like subjective norm, perceived behavioral control, and usage behavior constructs, were excluded from the constructed model. The reason is that VF is an innovation that people did not have many touchpoints with, as revealed by the qualitative analysis. Moreover, the constructed model focused on sustainability, as this is a significant factor within the context of VF (Grunert, 2011; Jürkenbeck et al., 2019; Van Loo et al., 2017).

All these constructs lead to the attitude towards buying vertical greens farmed in large-scale vertical farms. The constructed model is presented in *Figure 1*.

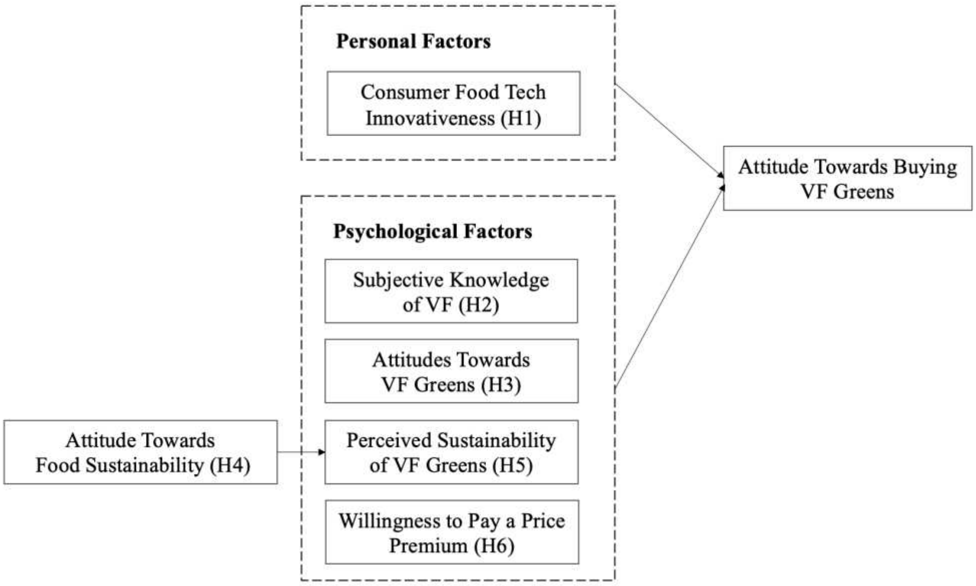

Figure 1: *Visualization of Constructed Model*

3.1 Consumer's Technological Innovativeness

Research has shown that vertical farms show the lowest level of general acceptance compared to other VF methods, such as home farms. Further literature revealed that large-scale vertical farms might be the most difficult method to achieve social acceptance with their high level of technological innovation (Specht et al., 2019; Specht, Weith, et al., 2016).

On the other hand, studies showed that people with a higher tendency to accept innovations are in general those who are concerned about the environment (Englis & Phillips, 2013). Studies in other industries also revealed that the degree of consumers innovativeness is crucial when it comes to the adoption of sustainable innovations (Noppers et al., 2015). These findings align with the statements of industry expert Maik Brinkkötter, former VF Director at Miele (Appendix 3.3). He pointed out that VF home systems, in general, gain higher acceptance rates because the consumer can actively be part of the cultivation process. Moreover, the expert highlighted people with an innovative nature as a main target group for VF products. These findings implicated that the adaption of VF as a sustainable and technological innovation might be influenced by an individual's level of innovativeness.

To further investigate the concept of consumer innovativeness in the context of VF, Rogers' Theory of Innovation was included. This theory defines the different stages of innovativeness. It describes that some people are more likely to adopt market innovations than others. As shown in *Figure 2*, it provides a framework to classify adopters into five different groups: (a)

Innovators, (b) Early Adopters, (c) Early Majority, (d) Late Majority, and (e) Laggards (Rogers, 2003; Flores & Jansson, 2021).

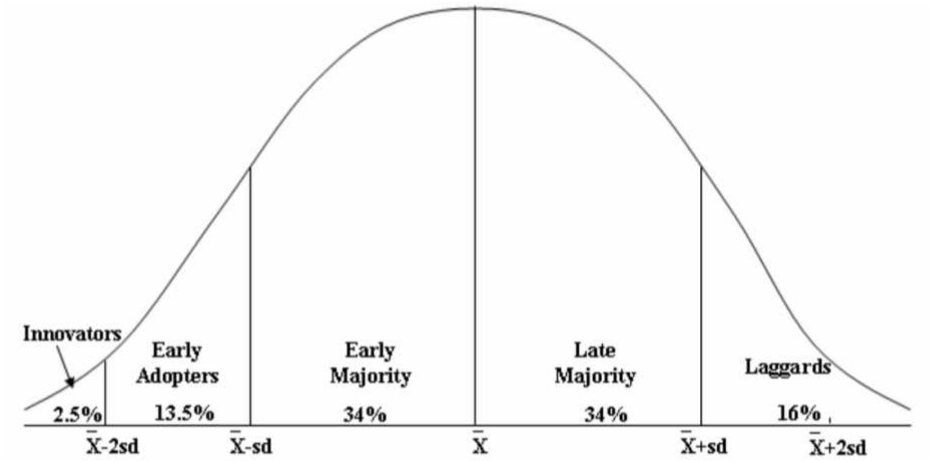

Figure 2: *Rogers' Different Stages of Innovativeness* (Sahin, 2006)

VF is a new approach to urban food production that raises uncertainties. For this reason, there might be differences between consumers with high and low affinities towards new food technologies (Perambalam et al., 2021). Therefore, the variable of consumer food tech innovativeness was included in the model, and the following hypothesis was proposed:

- ***H1:*** *The degree of innovativeness of the consumer is positively related to the attitude towards buying vertically farmed greens.*

3.2 Subjective Knowledge

Previous research showed that subjective knowledge is more important than objective knowledge when choosing environmentally friendly food (Peschel et al., 2016). Moreover, it validated that subjective knowledge can determine the quality of the consumer's decisions (Moorman et al., 2004). Literature also revealed a general lack of knowledge about VF and, therefore, a need to educate about urban agriculture (Grebitus et al., 2017; Jürkenbeck et al., 2019; Perambalam et al., 2021). Contrary, semi-structured consumer interviews revealed that consumers already have a basic understanding of VF and associate vertically grown greens with relevant characteristics (Appendix 5). Therefore, it is essential to include subjective knowledge as a construct when studying the consumer decision process around vertically farmed greens. The next hypothesis reads as follows:

- ***H2:*** *The subjective knowledge about VF affects the attitude towards buying vertically farmed greens.*

3.3 General Attitudes Towards Vertically Farmed Greens

Society is increasingly concerned about fresh vegetables' safety, security, consistency of supply, and price stability. VF could tackle this as the traceability of vertically grown vegetables is almost 100%, which can be a security factor for consumers. Moreover, there is a growing demand for functional fresh vegetables and medicinal plants, driven by concerns about health and improved quality of life (Kozai et al., 2020). People even tend to attach greater importance to health than sustainability factors (Van Loo et al., 2017). Consumers also considered naturalness, regionality, and the absence of pesticides essential in their choice of locally produced food (Aprile, et al., 2016; Specht, Siebert, et al., 2016). On top of that, the qualitative consumer interviews revealed further valued attributes such as taste, nutrients, and quality (Appendix 5).

On the other hand, there are potential barriers making people hesitant about the concept of VF. Literature supported this trend, showing that people still consider food from vertical farms less natural than traditional farming methods, which is underlined by industry experts and consumer interviews (Benke & Tomkins, 2018;Appendices 3 & 4). Another major barrier is the price, as revealed not only by industry experts but also through consumer interviews (Appendices 3 & 4). According to literature and industry experts, European markets have access to many high-quality products from greenhouses and are therefore not willing to pay a premium price for vertically grown products (Kozai et al., 2020; Appendix 3).

These potential drivers and barriers were the basis for the formulation of the following hypotheses:

- ***H3a:*** *The perception of vertically farmed greens as* ***innovative*** *has a positive relation with the attitude to buy such products.*
- ***H3b:*** *The perception of vertically farmed greens as* ***healthy*** *has a positive relation with the attitude to buy such products.*
- ***H3c:*** *The perception of vertically farmed greens as* ***fresh*** *has a positive relation with the attitude to buy such products.*
- ***H3d:*** *The perception of vertically farmed greens as* ***tasty*** *has a positive relation with the attitude to buy such products.*
- ***H3e:*** *The perception of vertically farmed greens as* ***safe*** *has a positive relation with the attitude to buy such products.*

- ***H3f:*** *The perception of vertically farmed greens as* ***artificial*** *has a negative relation with the attitude to buy such products.*
- ***H3g:*** *The perception of vertically farmed greens as* ***nutritious*** *has a positive relation with the attitude to buy such products.*
- ***H3h:*** *The perception of vertically farmed greens as* ***high quality*** *has a positive relation with the attitude to buy such products.*
- ***H3i:*** *The perception of vertically farmed greens as* ***more expensive*** *has a positive relation with the attitude to buy such products.*

3.4 Sustainable Consumption

Sustainability is a combination of economic, ecological, and social elements with a focus on fair pricing, environmental care, and alignment with social needs (Vermeir & Verbeke, 2008). The effects of COVID-19 and the increasing awareness about the ecological footprint of food, led to a change in attitudes towards food production. These trends drive an increased demand for locally produced food and a greater awareness among consumers who prioritize sustainability (McMichael et al., 2007; Moghimi, 2021; Specht et al., 2019). Research proved that the involvement level in sustainability emerges as a key trigger for sustainable consumption (Van Loo et al., 2017). Therefore, it is important to investigate general sustainable attitudes and how this affects the perceived sustainability of VF greens. The hypothesis reads as follows:

- ***H4:*** *The perceived sustainability of vertically farmed greens is positively affected by general interest in sustainable food production.*

Based on this relationship, the effect of the perceived sustainability of VF greens on the attitudes towards buying vertically farmed greens was investigated. That is because sustainability plays a crucial role within the context of VF. This new cultivation method not only allows an efficient use of resources but also the elimination of long-distance transportation due to localized production. All in all, VF aims to minimize the agricultural foodprint (Avgoustaki et al., 2021; Avgoustaki & Xydis, 2020; Despommier, 2011).

Therefore, consumers must perceive vertically farmed products as economically sustainable consumption to avoid negative environmental impacts. If this is the case, this perception might influence their purchasing behavior in a positive way, as proven by recent research (Hüttel et al., 2018). Literature validated that the factor of sustainability influences consumer's food choices. In particular, the perceived sustainability of VF can be described as one of the main drivers of its acceptance, which ultimately leads to the purchase of the product (Hüttel et al., 2018; Jürkenbeck et al., 2019). Moreover, studies have shown that large-scale VF systems are in general perceived as more sustainable due to the economies of scale (Jürkenbeck et al., 2019). The expert statement from Maik Brinkkötter underlined the theoretical findings. He pointed out that people who value sustainable practices and healthy living are key target personas for their VF home products (Appendix 3.3). On top of that, consumer interviews showed that people who generally value sustainable practices in the food sector also value the sustainable aspect of VF. Based on these findings, the following hypothesis was proposed:

- ***H5:*** *The attitudes towards the sustainability of VF positively affect the attitudes towards buying vertically farmed greens.*

3.5 Willingness to Pay a Price Premium

There is also a belief that local food is healthier and fresher, which leads to consumers making an extra effort to buy such products in terms of a higher willingness to pay for those premium products. Ultimately, consumers believe they support the local economy by buying food grown close to their homes (Feldmann & Hamm, 2015; Grebitus et al., 2013).

Compared to previous literature, exploratory research revealed results going in different directions. The expert interviews revealed a general low willingness to pay for VF products within Germany. Industry expert Stefano Augstburger highlighted Switzerland as an attractive market for VF as people value high quality and local production and show high expenditures for groceries (Appendix 3.2). The consumer interviews revealed split opinions on the willingness to pay a price premium for VF greens (Appendix 5). Therefore, the following hypothesis reads as follows:

- ***H6:*** *The general interest in paying a price premium for vertically farmed greens positively affects the attitudes towards buying such products.*

Concluding, this chapter led to the development of six central hypotheses answering the research questions based on an extensive literature review and the results of exploratory research. This led to the development of the framework and studies presented in the next chapter.

4 Methodology

This chapter includes an overview about how to answer the research questions of this thesis. It includes the overall research design, followed by an explanation of the target audience and the sample characterization for both studies. Afterwards, the exploratory research and descriptive research methodology will be explained separately.

4.1 Research Design

This study followed a mixed-methods approach as it combined exploratory and descriptive research. A combination of qualitative data from short interviews and quantitative data from a questionnaire aimed to solve the research problem.

Firstly, the objective of the exploratory research was to understand the current market situation to better understand the consumers' general level of knowledge and their perception of innovation. This step ensured that the research questions and hypotheses were addressed in a targeted and thorough manner.

Secondly, the descriptive part provided a description and analysis of the topic under investigation. This included the collection of quantitative data through a survey and the identification of relationships between variables within the constructed framework.

Finally, the results were analyzed and discussed. *Figure 3* illustrates the research design.

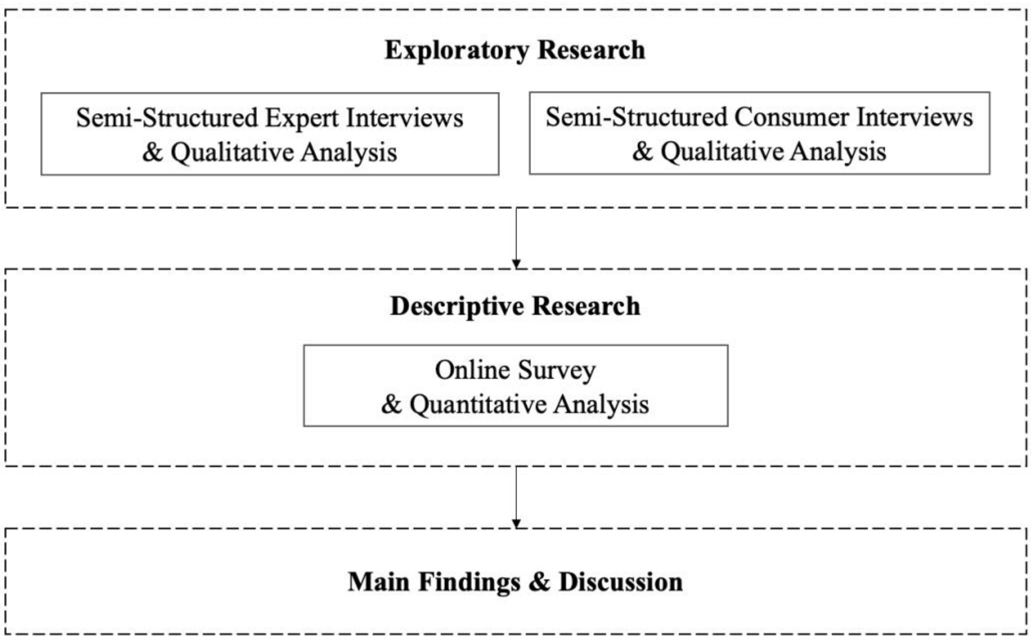

Figure 3: *Visualization of the Research Design*

4.2 Target Audience and Sample Definition

It was necessary to define the target group before specifying the sample. To do this, it was necessary to determine the group of people who were to be studied.

This study focused on young adults between the ages of 18 and 40. The reason is that VF's futuristic and innovative approach is most likely to influence these people. Furthermore, these young consumers have are crucial role in sustainable behavior and consumption (Hume, 2010). They are not only the next generation of adults but also have the power to consume and shop. Moreover, they have a strong influence on the food choices in their households (Vermeir & Verbeke, 2008). To suggest potential strategies for VF companies, it is crucial to study their attitudes regarding sustainable purchasing and consumption behavior. The German market was chosen as the target market as already explained further.

4.3 Exploratory Research

In general, qualitative research is characterized by its focus on context, interpretation, and the subjective meanings that individuals or groups attach to their experiences (Denzin & Lincoln, 2000). The semi-structured interviews, used in the study, enabled the researcher to adapt the questions based on the respondents' answers. Open-ended questions enabled respondents to elaborate on their views but also offered the opportunity to give more narrative responses. Therefore, the developed interview guides served more as a framework to ensure a certain degree of consistency across all the interviews and to keep focus on the initial research questions (Appendices 2 & 4).

4.3.1 Research Design and Data Collection

For the expert interviews, eight open-ended questions were constructed (Appendix 2). The experts were contacted through LinkedIn based on their professional profile and diverse touchpoints with the VF industry. This allowed a comprehensive perspective on the topic under investigation. All interviews were conducted via Google Meet between November 11th and 16th, 2023. The interview included a subjective assessment of the market situation, questions regarding the specific constructs within the framework, and a question regarding the future of large-scale VF. *Table 1* presents an overview of all interview partners.

Interviewee	Date	Company	Position	Duration
Anonymous	09.11.2023	European VF Company (Anonymous)	Strategy & Business Development Manager	30 minutes
Stefano Augstburger	14.11.2023	YASAI	Co-CEO & Chairman	30 minutes
Maik Brinkkötter	16.11.2023	Miele / Agrilution	Director VF	30 minutes

Table 1: *Overview Semi-structured Expert Interviews*

In parallel, ten semi-structured consumer interviews with eight open-ended questions were run (Appendix 4). These interviews aimed to gain a broad understanding of VF's awareness and perceptions and identify relevant variables for the quantitative research part. The participants were selected intentionally to guarantee a variety of perspectives. Sampling criteria were based on age (between 18 and 30), residence (living within an urban area), and experiences related to the food tech sector (showing a general interest in food innovation topics). All consumer interviews were conducted in person between November 12th and 16th, 2023. The participants were interviewed about their prior knowledge of VF, their associations with the term, their psychological attitudes, and their willingness to pay more (Appendix 5).

4.3.2 Measurement and Data Analysis

The data analysis for the quantitative part used the thematic analysis method. This method identifies, analyzes, and reports patterns in qualitative data (Braun & Clarke, 2006). Firstly, the data from the interview notes were simplified. Afterwards, the data was organized based on the research questions, defined into themes, and synthesized into a table (Appendix 5). Finally, the research questions and hypotheses were sharpened based on these outcomes.

4.4 Descriptive Research

The quantitative approach was used to test objective theories by examining the relationship between variables that can be measured and analyzed using statistical tools and techniques (Creswell, 2014). An online questionnaire was chosen as the research method because it provides the opportunity to collect data from a large number of participants and to target a specific group.

4.4.1 Research Design and Data Collection

This study used a quantitative online survey. Moreover, the tool Qualtrics was used to validate the research hypotheses. The online survey was conducted between November 18th and November 30th, 2023. It was shared via the social media platforms WhatsApp, LinkedIn and Instagram. The goal was to cover a wide range of education levels and genders. The stratification criteria were the following: (1) the respondent lives in Germany, and (2) the respondent is a minimum of 18 years old. The survey presented 15 questions to the participants. It was divided into five sections: (1) stratification criteria, (2) general attitudes innovation and sustainability in the food sector, (3) prior knowledge about VF, (4) attitudes towards vertically farmed greens and perceptions of sustainability of vertically farmed greens, and (5) demographics.

The descriptive data was collected by using a non-probability sampling technique. Moreover, this study went with convenience sampling, and respondents participated voluntarily and consented to participate (Malhotra et al., 2017). Participants were recruited through social media using a snowball sampling method (Naderifar et al., 2017).

A total of 174 people answered the survey, but only 132 responses were considered valid. The reason was that ten answers were invalid due to the screening question, 17 participants failed the control question, and 22 people did not complete the survey to the end. *Table 2* provides an overview of the research framework and the quantitative testing approach.

Constructs	Variables	Questions	Sources
Consumer's Food Tech Innovativeness (H1)	Innovators	I am someone who keeps up with new advances in food technology and takes risks by being the first to buy an innovative food product, regardless of what function it is performing.	(Flores & Jansson, 2021; Noppers et al., 2015; Sahin, 2006)
	Early Adopters	I am someone who wants to see the benefits of new ideas in the food sector and then be one of the first to make use of them.	
	Early Majority	I am someone interested in new food products, but my decisions are largely influenced by the suggestions made by current users who fully tested the product.	
	Late Majority	I prefer safe food options to exciting new products in the food industry. For me to consider an innovative food product, it must have been on the market for some time and have a clear benefit.	
	Traditionalists	I prefer traditional food and I am not interested in trying innovative food products. I do not enjoy changes in life and I only buy an innovative food product when the existing model I use is no longer available.	

Subjective Knowledge (H2)		- I am familiar with the concept of VF. - I know how to judge the quality of a vertical farmed greens. - I think I know enough about vertical farmed greens to feel pretty confident when I make a purchase. - I do feel very knowledgeable about VF. - Compared to most other people, I know a lot about VF. - When it comes to VF, I really do know a lot. - I can tell if a vertical farmed green is worth the price or not.	(Noppers et al., 2015; Flynn & Goldsmith, 1999; Moorman et al., 2004)
Attitudes Towards VF Greens (H3)	Innovativeness	I think vertically farmed greens are **innovative**.	(Grebitus et al., 2017; Al-Kodmany, 2018; Consumer Interviews (Appendix 5))
	Health	I think vertically farmed greens are **healthy**.	
	Freshness	I think vertically farmed greens are **fresh**.	
	Taste	I think vertically farmed greens are **tasty**.	
	Safety	I think vertically farmed greens are **safe**.	
	Artificiality	I think vertically farmed greens are **artificial**.	
	Nutrient Level	I think vertically farmed greens are **nutritious**.	
	Quality	I think vertically farmed greens are **high quality** products.	
	Price	I think vertically farmed **greens are worth to pay more** for than conventional farmed greens.	
General Attitude Towards Food Sustainability (H4)		- The sustainability of food has a big impact on my food choices. - I care a lot about the sustainability of food. - A healthy diet is important to me. - I always eat food with a sustainable background. - The sustainability of snacks makes a difference to me. - I avoid food that is not sustainable.	(Roininen et al., 1999)
Perceived Sustainability of VF Greens (H5)	Environmental Impact	I think vertical farmed greens **come from close by**.	(Vermeir & Verbeke, 2008; Al-Kodmany, 2018)
		I think vertical farmed greens are a **local product**.	
		I think vertical farmed greens produce **minimal CO2 emissions**.	
		I think vertical farmed greens are produced without **disturbing the balance of nature.**	
		I think vertically farmed greens are produced in an **environmentally friendly way**.	
		I think the production of vertically farmed greens **conserves resources**.	
Willingness to Pay a Price Premium (H6)	Price Premium	Would you be willing to pay a price premium for vertically farmed greens?	(Grebitus et al., 2017)
Attitude Towards Buying VF Greens (Dependent Variable)	Attitude Towards Buying	- I am positive towards a purchase of vertically farmed greens. - I am likely to buy a vertically farmed green if it is available at my local supermarket. - I would like to try a vertically farmed green.	(Jürkenbeck et al., 2019)

***Table 2**: Quantitative Research Framework*

4.4.2 Measurement and Data Analysis

The quantitative research questionnaire used a five-point Likert scale ranging from 1, which indicated complete disagreement, to 5, which indicated complete agreement. As stated by Joshi et al. (2015), the Likert scale is easy to create and manage because respondents easily understand how to use it, and results can be easily quantified. A potential limitation of the Likert scale is that respondents may focus their responses on the middle of the scale. For the construct of subjective knowledge, a distinct variable, "Have you ever bought a product grown in a vertical farm?" was used, which consisted of three options ("Yes"/"No"/"I don't know"). Moreover, the question about the type of innovativeness included a categorial variable with five options, and the question about the willingness to pay a price premium included a distinct non-metric variable with two options ("Yes"/"No"). Attitude towards buying, as posed as the dependent variable, was metric. The different constructs used in the answer options combined original construct versions and constructs that were slightly adapted to better fit this research (Table 2). For more details on the exact survey structure and variables, see *Appendix 6*.

The survey data was analyzed using IBM SPSS statistical software to validate the hypotheses and answer the six research questions. The analysis included the characterization of the sample in terms of demographics, innovation behavior, interest in food sustainability, and subjective knowledge of VF. To characterize the data, frequencies were used along with measures of central tendency (mean) and measures of variation (standard deviation, maximum, and minimum). Afterwards, consistency and reliability were determined using Cronbach's alpha coefficient (Nunnally, 1979; Cronbach, 1951). The classification and therefore, the evaluation of Cronbach's Alpha is illustrated in *Table 3*.

Cronbach's Alpha	Internal Consistency
$\alpha \geq 0.90$	Excellent reliability
$0.80 \leq \alpha < 0.9$	Good reliability
$0.70 \leq \alpha < 0.8$	Acceptable reliability
$0.60 \leq \alpha < 0.7$	Questionable reliability
$0.50 \leq \alpha < 0.6$	Poor reliability
$\alpha < 0.50$	Unacceptable reliability

Table 3: *Classification of Cronbach's Alpha (Gliem & Gliem, 2003)*

Further analysis within this research included statistical tests and linear regressions with the goal to study the relationships between the constructs. As the study's dependent variable was continuous, a multiple regression was appropriate. The t-test and cross-tabulation analysis compared the means among the different groups. Moreover, two correlations were carried out in order to determine the strength and the direction of the relationships between the variables.

5 Main Findings

Exploration and descriptive research were conducted to better understand consumers' motives and attitudes towards vertically farmed greens. Thereby, a central research question with six sub-questions was tested. The following chapter starts with a sample characterization of all conducted studies. Afterwards, the main findings of the exploratory consumer interviews are summarized by referring to a thematic analysis. The descriptive research, in more detail, the online survey data, was analyzed using SPSS.

5.1 Sample Characterization

Ten semi-structured interviews were conducted for the qualitative analysis. The participants were aged between 21 and 34 years, with four men (40%) and six women (60%) from Germany. Five of these participants were full-time employed (50%), four were students with a job (40%), and one was a student without a job (10%). All participants prior indicated interest in innovations in the food sector.

The quantitative analysis collected a convenience sample of 132 valid questionnaire respondents. Most of the participants were female (65.9%) and most of them were between 25 and 32 years old (63.6%). Only 15.2% of the participants were more than 32 years old. As it was a sampling criterion, all respondents were from Germany. The majority of the participants lived in large cities such as Hamburg (41.7%), Bremen (13.6%), and Berlin (12.1%). The sample showed highly educated respondents, as 69 had a Bachelor's degree (52.3%), and 42 had a Master's degree (31.8%). There were also three participants with a doctorate or professional degree (2.3%). Only a minority of the sample had a secondary education (12.1%) or no formal education (1.5%). Regarding their occupation, most of the respondents indicated having a full-time job (56.8%). In comparison, 29 were students with jobs (22%) and 15 students without a job (11.4%). Out of the remaining respondents, three had a part-time job (2.3%), four were retired (3.0%) and five indicated 'Other' work situation (3.8%). These findings go in line with the total household income before taxes during the past 12 months, with approximately 31.8% of the participants earning between 50,000€ and 99,999€ per year, 27.3% earning less than 25,000 € per year, and 24.2% had an income around 25,000€ to 49,999€ per year. Only 12.9% of the participants had an income higher than 100,000€ per year. For further information on the sociodemographic characteristics, see *Table 4* and *Appendix 7*.

Characteristics		Frequency (N=132)	Percentage (%)
Gender			
	Male	45	*34.1*
	Female	87	*65.9*
Age group (in years)			
	18 – 24	28	*21.2*
	25 – 32	84	*63.6*
	33 – 40	7	*5.3*
	+ 40	13	*9.8*
Education			
	No Formal Education	2	*1.5*
	Secondary Education	16	*12.1*
	Bachelor's Degree	69	*52.3*
	Master's Degree	42	*31.8*
	Doctorate or Professional Degree	3	*2.3*
Profession			
	Student without a Job	15	*11.4*
	Student with a Job	29	*22.0*
	Full-time Job	75	*56.8*
	Part-time Job	3	*2.3*
	Unemployed	1	*0.8*
	Retired	4	*3.0*
	Other	5	*3.8*
Income before taxes (in € per year)			
	Less than 25,000 €	36	*27.3*
	25,000 - 49,999 €	32	*24.2*
	50,000 - 99,999 €	42	*31.8*
	100,000 - 199,999 €	15	*11.4*
	More than 200,000 €	2	*1.5*
	Prefer not to say	5	*3.8*
Home City			
	Hamburg	55	*41.7*
	Bremen	18	*13.6*
	Berlin	16	*12.1*
	Munich	9	*6.8*
	Cologne	6	*4.5*
	Stuttgart	6	*4.5*
	Frankfurt	5	*3.8*
	Somewhere else	17	*12.9*

Table 4: *Summary of Survey Sample Characteristics*

5.2 Exploratory Research: Semi-structured Interviews

In the following, the results of the ten semi-structured consumer interviews are presented. Even though VF is not a present agricultural concept in Germany at the moment, the respondents indicated a general understanding of the VF constructs, its benefits, and challenges. In particular, the participants named associations with VF such as high-tech, efficient, sustainable, fully controlled, and located within urban areas. Moreover, the predominant association with large-scale commercial farms became clear as only a few participants associated VF with small, home-grown systems.

After an interrogation about their general association with the term VF, the participants got a brief introduction to level their knowledge and understanding of VF. Then they were asked about aspects and product attributes that could potentially influence their purchase as well as possible concerns and reservations towards the consumption of vertically farmed greens. The identified variables correlated with those found in theoretical analysis, like high product quality, reduced pesticide use, freshness, healthiness, and sustainability. However, the participants also expressed skepticism about the naturalness of the products and uncertainty about the actual environmental impact vertical indoor farms potentially have.

When asked about their sustainable consumption behavior and attitudes towards sustainability, all participants reported the importance of this factor in their daily food choices. Among the key attributes contributing to the perceived sustainability of VF were efficient reduced water usage, short transportation distances, reduced pesticide use, and optimal use of space. However, respondents expressed concerns about the high energy consumption associated with VF.

Answers on the attitudes towards purchasing vertically farmed greens showed that price, taste, and quality are key decision factors. Some participants stated an interest in collecting further information about VF before making a purchase. Overall, there was a positive consideration and mindset towards the concept of vertical urban farming among the participants.

However, those who prioritize food innovation and sustainability and had significant prior knowledge indicated a willingness to pay a price premium for vertically farmed products. In contrast, participants who did not value sustainability that much were not willing to pay a price premium but expressed potential reconsideration if vertically farmed greens would offer exceptional product qualities. Concluding, there were mixed results on the willingness to pay a price premium for VF products.

Appendix 5 summarizes the key findings and presents a thematic analysis.

5.3 Descriptive Research: Online Survey

5.3.1 Descriptive Statistics

The descriptive statistics indicated that the different types of innovators indicated by the participants were relatively unevenly distributed between the Early Majority (33.3%), Early Adopters (29.5%), Late Majority (17.4%), Innovators (16.7%), and Traditionalists (3.0%). A minority of participants (12.9%) had already tried vertically farmed products. In comparison, 49 participants had never tried them (37.1%), and 66 participants did not know if they had ever tried them (50%). In terms of willingness to pay, the results indicate relatively evenly distributed outcomes. 55.3% of the people indicated to be willing to pay more for a vertically farmed green and 44.7% indicated not to be willing to pay more. For more detailed results, see *Table 5* or *Appendix 8*.

Characteristic		Frequency (N=132)	Percentage (%)
Innovator type			
	Innovators	22	16.7
	Early Adopters	39	29.5
	Early Majority	**44**	**33.3**
	Late Majority	23	17.4
	Traditionalists	4	3.0
Bought a product grown in a VF			
	Yes	17	12.9
	No	49	37.1
	I don't know	**66**	**50.0**
Willing to pay a price premium for VF greens			
	Yes	73	55.3
	No	59	44.7

Table 5: *Descriptive Statistics of Attitudes Towards Innovation and VF*

A one-sample t-test was run to figure out if there are potential differences between the five main constructs used in this study. The results indicate that *buying VF greens* is the attitude that the participants favor the most, with a mean result of 4.14 (SD = 0.757). In contrast, the construct *subjective knowledge of VF* reveals the most significant gap (M = 2.48; SD = 0.915). Except for subjective knowledge of VF, all results are between 1.50 and 5.00. It can be concluded that there is a tendency to have a favorable attitude, as all of the constructs show a mean above 3, which indicates neutral, besides the construct *subjective knowledge of VF*. In *Table 6,* the median, mean, standard deviation, and p-value of the five constructs used in this study are presented. A more detailed output on the descriptive statistics is in *Appendix 9*.

Constructs	Min - Max	Median	Mean	SD	t (131)	p-value
Q5. Attitudes Towards Food Sustainability	1.50 – 5.00	3.50	3.42	0.760	6.393[a]	<0.001
Q7. Subjective Knowledge of VF	1.00 – 4.67	2.50	**2.48**	0.915	-6.529[a]	<0.001
Q8. Attitudes Towards VF Greens	2.75 – 5.00	4.00	3.96	0.505	21.763[a]	<0.001
Q9. Perceived Sustainability of VF Greens	1.60 – 5.00	4.00	3.86	0.642	15.451[a]	<0.001
Q10. Attitudes Towards Buying VF Greens	1.67 – 5.00	4.33	**4.14**	0.757	2.183[b]	0.015

Scale from 1 = Strongly Disagree to 5 = Strongly Agree; p = one-sided p-value

***Table 6**: Descriptive Statistic of the Framework Constructs*

As previous studies proved that age is an important predictor of innovation adaption, further analysis was conducted (Bartels & Reinders, 2011). A Cross-Tabulation was performed in order to figure out if there are significant differences between the different age groups and genders on the attitudes towards buying. Even though the results show that the youngest age group (people between the ages of 18 and 24) present the most favorable attitude towards buying, these results were not significant. Moreover, there was not a significant difference between the gender of the people and the buying behavior.

Before carrying out further analysis, the Mahalanobis distance was used to clean the data from potential multivariate outliers. As shown in *Table 7*, the Mahalanobis values are between 0.29955 and 20.29191, which leads to significant p-values between 0.0011 and 0.9977 (Table 7). No outliers were identified in the data as all p-values were above 0.001.

	N	Minimum	Maximum
Mahalanobis Distance	132	0.29955	20.29191
Prob_MAH	132	0.0011	0.9977

***Table 7:** Mahalanobis Distance and p-values*

5.3.2 Reliability and Internal Consistency

To ensure a valid analysis, several tests were run that can be found in *Appendices 9-11*. Different tests indicated that the distribution is non-normal. Cronbach's alpha was used to measure the reliability of the five constructs used in this study. Therefore, the corrected item-total correlation of each item was analyzed, which presents the correlation between the item and the scale score without the item in reference. Moreover, the corrected Cronbach's with the deleted items was presented (Appendix 10).

The combination of the different variables within the construct's *attitudes towards food sustainability*, *subjective knowledge of VF*, and *attitudes towards buying VF greens* indicated good to excellent reliability, with Cronbach's Alpha between 0.879 and 0.909 (based on Table 3), indicating a good internal consistency.

On the other hand, Cronbach's Alpha of the construct's *attitudes towards VF greens* and *perceived sustainability of VF greens* was raised by the elimination of statements with a low discrimination index. Therefore, the question "*I think vertically farmed greens are artificial*." and "*I think vertical farmed greens come from near where I live."* were eliminated. Ultimately, all constructs represented a good internal consistency and a corrected item correlation above 0.3, indicating a good discrimination index (Cronbach, 1951). The final Cronbach's alpha is presented in *Table 8*.

Constructs	**Cronbach's Alpha (N=132)**
Q5. Attitudes towards Food Sustainability (6 items)	0.879
Q7. Subjective Knowledge of VF (6 items)	0.909
Q8. Attitudes towards VF Greens (8 final items)	0.834
Q9. Perceived Sustainability of VF Greens (5 final items)	0.802
Q10. Attitude towards Buying VF Greens (3 items)	0.889

Table 8: *Cronbach's Alpha*

5.3.3 Hypotheses Testing

In order to analyze H1, the **Kruskal-Wallis test** was chosen, since the parametric assumption for the ANOVA test is not accomplished in three of the groups.

The results are presented in *Table 9* and show that the less innovative the type of participant, the lower the *attitude towards buying VF greens*. The Innovators show the highest mean (M = 4.64; SD = 0.470), followed by the Early Adopters (M = 4.34; SD = 0.703) and Early Majority (M = 4.02; SD = 0.437) with means all above four. On the other hand, the Traditionalists present the lowest mean (M = 2.75; SD = 1.067), but also the Late Majority innovator type presents *an attitude towards buying VF greens* with a mean below four (M = 3.83; SD = 1.009). The higher means for the more innovative groups and the low standard deviation for the Innovators (SD = 0.470) and Early Majority (SD = 0.437) indicate a more consistent *attitude towards buying VF greens*.

As the p-value of the test reveals a significant effect, it can be validated that there are significant differences between the participants of the different innovator levels in regard to their *attitude towards buying VF greens* ($H_{(4)}$= 28.273; $p < 0.001$). Concluding, Early Adopters have a more favorable *attitude towards buying VF greens* than the Early Majority (post-hoc test: Bonferroni, $p < 0.05$). Therefore, **H1** is validated since higher innovator types are associated with more favorable attitudes towards buying VF greens. All of this is presented in *Table 9*. A more detailed test output can be found in *Appendix 11*.

Innovator Type	**N**	**Mean**	**SD**	**Kruskal-Wallis H**	**p-value**
Innovators	22	4.64^{123}	0.470	28.273	< 0.001
Early Adopters	39	4.34^{4}	0.703		
Early Majority	44	4.02^{34}	0.437		
Late Majority	23	3.83^{2}	1.009		
Traditionalists	4	2.75^{1}	1.067		

Same reference numbers indicate significant differences 4. p<0.05 1.2 p < 0.01 3. p <0.001

Table 9: *Kruskall-Wallis Test*

To test the strength and direction of the linear relationships between the different constructs within the physiological part of the framework, the **Pearson correlation** was used. The fact that all the constructs were continuous variables with approximately normal distributions allowed this testing.

All the constructs indicated a positive significant relationship with a p-value lower than 0.01. The positive correlations indicated that all constructs vary in the same direction, so if one variable increases, the other increases as well. Moreover, all constructs show relations of moderate intensity with the dependent variable *attitude towards buying VF greens*, varying between 0.515 and 0.696 ($p < 0.001$). Further positive relationships with moderate intensity are presented in *Table 10*. Two relationships within the testing outcome can be described as low intensity, which is the *attitude towards food sustainability* with *perceived sustainability of VF greens* ($r = 0.036$; $p < 0.001$) and the *subjective knowledge of VF* with *perceived sustainability of VF greens* ($r = 0.374$; $p < 0.001$). A detailed correlation matrix, including all variables as described above, can be found in *Appendix 12*.

	Q7. Subjective Knowledge of VF	Q8. Attitudes towards VF Greens	Q9. Perceived Sustainability of VF Greens	Q10. Attitude towards Buying VF Greens
Q5. Attitude towards Food Sustainability	.474***	.454***	.336***	.520***
Q7. Subjective Knowledge		.584***	.374***	.515***
Q8. Attitudes towards VF Greens			.655***	.696***
Q9. Perceived Sustainability of VF Greens				.636***

*** *significant for p-value < 0.01*

Table 10: *Correlation Analysis*

A simple **linear regression** analysis model was performed to assess the effect of general *attitude towards food sustainability* over the dependent variable *perceived sustainability of VF greens*. One of the cases was eliminated from the model, because it was an extreme standardized residual. Therefore, the model was performed with 131 cases. The effect proved to be statistically significant ($F(1,129) = 19.583$; $p < 0.001$) explaining 13.2% of dependent variables variance (Table 11). In this case, the positive B coefficients which is equal to 0.292 shows that the *perceived sustainability of VF greens* increases as *attitudes towards sustainable consumption* increase. Concluding, the results show that the general *attitude towards food sustainability* has a positive significant effect on *perceived sustainability of VF greens* and therefore **H4** is supported. For the whole analysis see *Appendix 13*.

Predictor	**B**	**Std. Error**	**t**	**p**	**CI 95% for B**	
Constant	2.883	0.231	12.474	< 0.001	2.425	3.340
Attitude towards Food Sustainability	0.292	0.066	4.425	< 0.001	0.161	0.422

$F_{(1, 129)} = 19.583$; $p < 0.001$; $R^2 = 0.132$ $R^2_{Ajust} = 0.125$
Dependent variable: perceived sustainability of VF greens; B. Unstandardized coefficients

Table 11: *Linear Regression Analysis*

In order to test the hypotheses H3, H5, and H6, a **multiple linear regression** analysis was performed. The model proved to be statistically significant ($F = 43.540$; $p < 0.001$), explaining 57.8% of the dependent variables *attitude towards buying VF greens* variance (R2 = 0.578; R2Ajust = 0.565). The regression formula can be written as follows:

$$\textit{Attitudes Towards Buying}_i = 0.792 + 0.114\, SK + 0.477\, Att_i + 0.396\, PerSus_i - 0.241\, WTP\, PP_i \quad i = 1,\dots, 132$$

The two predictors' *attitudes towards VF greens* (B = 0.477; t = 3.453; p < 0.001; CI 95% [0.204; 0.750]) and *perceived sustainability of VF greens* (B = 0.396; t = 4.383; p < 0.001; CI 95% [0.217; 0.575]) revealed a positive significant effect on the dependent variable with a significance level below 0.05 which validates **H3** and **H5**. The *willingness to pay a price premium for VF greens* also had a significant negative effect on the dependent variable (B = -0.241; t = -2.364; p = 0.020; CI 95% [-0.443; -0.039]). It can be concluded that participants who are not willing to pay a price premium for VF greens have a lower attitude towards buying a VF greens (B = 0.241), which supports **H6**. The construct *subjective knowledge of VF* does not have a significant effect on the dependent variable with a p above 0.05, which does not support **H2**.

The construct *perceived sustainability of VF greens* has the biggest impact on the dependent variable with a Beta of 0.336. However, the construct *attitudes towards VF greens* has a large Beta with 0.318 (Beta = 0.318). The predictor *willing to pay a price premium for VF greens* has a lower effect with a beta of -0.159. As the B coefficients of *attitude towards VF greens* is positive correlated and equal to 0.477, this indicates that for each unit increase, consumer's attitude towards a purchase will increase by 0.477 units. All results are presented in *Table 12*.

Predictors	**B**	**Std. Error**	**Beta**	**t**	**p**	**CI 95% for B**	
Constant	0.792	0.482		1.646	0.102	-0.160	1.745
Subjective Knowledge of VF	0.114	0.060	0.138	1.911	0.058	-0.004	0.232
Attitudes towards VF Greens	0.477	0.138	0.318	3.453	<0.001	0.204	0.750
Perceived Sustainability of VF Greens	0.396	0.090	0.336	4.383	<0.001	0.217	0.575
Willing to pay a price premium for VF greens (a)	-0.241	0.102	-0.159	-2.364	0.020	-0.443	-0.039

$F_{(4, 127)} = 43.540$; $p < 0.001$; $R^2=0.578$; $R^2_{Ajust}=0.565$; Dependent variable: Attitude towards Buying VF Greens
B. Unstandardized Coefficients Beta; Standardized Coefficients (a) Reference category: YES

Table 12: *Multiple Regression Analysis*

Furthermore, the results do not indicate any sign of multicollinearity as the values of Tolerance and VIF are not critical with a VIF < 5 and Tolerance values > 0.1 (Appendix 14). In conclusion, H3, H5, and H6 can be validated, and H2 can be rejected.

A **Spearman correlation** was performed to further investigate the strength of the relation between the different attitudes, defining the construct of H3. The participants received nine questions on specific attributes related to VF, which results provide insights into the main reasons to encourage or prevent consumers from buying VF greens.

The results presented in *Table 13* show that all the perceptions have positive significant correlations with the *attitude towards buying VF greens*, except for the perception of VF greens as artificial, which shows a negative correlation. The perception of VF greens as healthy shows a higher relation with the *attitude towards buying VF greens* (rs = 0.631; $p < 0.001$), followed by the perception as fresh (rs = 0.553; $p < 0.001$) and safe (rs = 0.524; $p<0.001$). The perception of VF greens as innovative (rs = 0.454; $p<0.001$), high quality (rs = 0.446; $p < 0.001$), and nutritious (rs = 0.431; $p < 0.001$) are of moderate intensity. A low intensity exists for the perceptions as tasty (rs = 0.370; $p < 0.01$) and worth paying more for (rs = 0.350; $p < 0.001$), which, however, are positive.

The lowest relation is presented by the perception as artificial, which is also negative (rs = -0,339; $p < 0.001$), which means that the higher the participants consider VF greens as artificial, the lower their attitude towards buying such a product. Therefore, the hypothesis **H3a**, **H3b**, **H3c**, **H3d**, **H3e**, **H3g**, **and H3h** can be confirmed, and **H3i** cannot. For all results of the Spearman correlation, see *Table 13,* and *a* detailed SPSS output for the test outcome is in *Appendix 12*.

H3	VF Attributes	Attitude Towards Buying VF Greens
a	I think vertically farmed greens are **innovative**.	0.454^{***}
b	I think vertically farmed greens are **healthy**.	0.631^{***}
c	I think vertically farmed greens are **fresh**	0.553^{***}
d	I think vertically farmed greens are **tasty**	0.370^{***}
e	I think vertically farmed greens are **safe**	0.524^{***}
f	I think vertically farmed greens are **artificial**.	-0.339^{***}
g	I think vertically farmed greens are **nutritious**.	0.431^{***}
h	I think vertically farmed greens are **high quality**.	0.446^{***}
i	I think vertically farmed greens are **worth paying more for** than conventionally farmed greens.	0.350^{***}

*** *significant for p-value <0.001*

Table 13: *Relations of the Construct H3*

6 Discussion

Results showed several factors positively influencing a consumer’s attitude towards buying vertically farmed greens. In the following, the results of the studies are discussed, managerial and theoretical implications are given, and limitations and potentials for future research are examined.

6.1 Research Findings

Our world is facing a climate crisis and a limited amount of resources, with which it will not be possible to feed the world population in the near future. At this point, innovation in the food technology sector becomes crucial in order to come up with potential solutions, like Vertical Farming, which was the main motivator for this study. Extensive research was conducted to gain a better understanding of the underlying interests and attitudes towards vertical-farmed greens. To address the research problem, six research questions and hypotheses were formulated and analyzed. Overall, the results showed that consumers' innovativeness, perceived sustainability, willingness to pay a premium, and attitudes towards VF greens significantly predict consumers' attitudes towards buying. In the following chapter, the results will be examined further.

The trait of consumers’ innovativeness significantly correlates with the attitudes towards buying a vertically farmed green. **H1** was supported by the results, showing that the more innovative the consumer is, the more favorable attitudes towards buying and trying VF greens persist. This goes in line with previous research, which revealed that consumer innovativeness is an essential factor in adopting sustainable innovations, as VF aims to be (Noppers et al., 2015; Perambalam et al., 2021). On top of that, these findings align with the expert interviews, which defined innovative people as a main target group. Moreover, the degree of innovativeness proves that VF is still perceived as an innovation in the German market that attracts primarily the people who feel closer to innovation. Therefore, considering consumer and product innovativeness in understanding and predicting attitudes towards vertically farmed greens is essential.

Most participants never, or at least do not precisely remember, buying indoor VF products before. This fact was underlined by the general subjective knowledge about the topic of VF, which was very little. Consequently, the subjective knowledge, meaning the prior knowledge about the VF industry, does not seem to have a significant influence on the attitudes towards buying VF greens. Thus, **H2** was not supported. However, this goes in line with some other studies that also examined the effect of subjective knowledge on different vertical farming systems (Grebitus et al., 2017; Jürkenbeck et al., 2019). An explanation could be that more educational communication about VF in general and on specific VF product characteristics is necessary for consumers to feel more knowledgeable about VF and incorporate their knowledge in their purchase decisions. The results of the quantitative customer analysis go against the results of the qualitative analysis, which indicated that people already have a solid base knowledge about the topic. However, the fact that people with a general interest in food innovation were interviewed in the qualitative part might be the reason.

Results regarding the diverse attitudes towards VF greens indicate that consumers generally have a positive attitude towards urban agriculture. The one-sample t-test revealed the highest mean for the overall construct of VF attitudes, showing a generally favorable perception of indoor grown greens. Indeed, **H3** was supported and showed a significant effect of the attitudes towards VF on the positive attitude towards buying such a product. Not only do these attitudes have a positive, significant effect, but based on the analysis, they show the overall strongest effect on the dependent variable. Moreover, these constructs show a strong effect on the construct of perceived sustainability within the correlation analysis. Research results on the specific attributes of vertically farmed products show that freshness, healthiness, quality, and safety are the main reasons to encourage people to buy vertically farmed greens. Contrary to the results of H1, the product characteristic of innovativeness is not as crucial as other factors. Factors that might prevent customers from buying seem to be artificialness, as this factor has a significant, negative correlation with the attitude towards buying which goes in line with previous research (Benke & Tomkins, 2018).

The correlation analysis proved that there is a relationship between the variables general attitudes towards sustainability and perceived sustainability of VF greens, but only with low intensity. Furthermore, the linear regression indicated a positive significant effect of general attitudes on perceived sustainability, which supports **H4**. This suggests that the general social awareness of sustainable consumption has a positive effect on the perception of vertical farms.

The study results of the descriptive analysis indicate that the perceived sustainability of VF green has a positive, significant effect on the attitudes towards buying vertically farmed greens, and therefore **H5** was also supported. Even though the general attitudes towards sustainable food consumption are only slightly above a neutral standing within the sample, the perceived sustainability seems to be a crucial and outstanding factor. The perceived sustainability might not be one of the main drivers in the context of VF greens, contrary to what was indicated by prior research, but it is still crucial in the context of VF (Despommier, 2009; Hüttel et al., 2018; Jürkenbeck et al., 2019). These findings were revealed through linear regression and correlation analysis.

These findings about the relevance of sustainable consumption go against the current state of VF in the market, as stated by the expert Stefano Augstburger and another anonymous expert (Appendix 3). The two experts emphasized that even though VF often gets connected to sustainable consumption, it does not have a sustainable nature at this point of technological progress. As a result, VF is perceived as a sustainable consumption option that might enhance the buying behavior of potential customers in the future but also brings up potential for further research and development.

Based on the descriptive analysis, the factor of willingness to pay a price premium was incorporated in this study as it was often mentioned as a crucial factor within the context of VF products. The results revealed a significant effect of this construct on the dependent variable, purchase and usage behavior, which validates **H6**. The quantitative statistics emphasized that the willingness to pay a price premium is evenly divided within the sample. As the statistical analysis further validated H6, it can be concluded that people who are willing to pay a price premium are also those who are willing to try and buy VF greens. This goes in line with previous research, which indicated that people are willing to make an extra effort, in this case, expenses, to buy a local product (Feldmann & Hamm, 2015; Grebitus et al., 2013). There seems to be a mindset shift or a general trend in society that goes towards local and higher-quality food, especially when targeting people with a high awareness of sustainable consumption, as was the case in this study. These findings contradict expert interviews stating that VF greens should not be any more expensive than conventional farmed ones. It might be a crucial factor to investigate the exact price spectrum further, but based on the analysis, it seems that price has less impact on buying behavior than other factors, as mentioned before. Therefore, the study's results indicate that the prices of VF greens might be raised, offering new opportunities for companies in the market.

6.2 Theoretical Implications

There is an increasing number of studies about VF in recent years, which illustrates the increasing relevance of this topic. Nevertheless, there are some research gaps, especially in studying consumer attitudes and consumer traits regarding those innovations. Moreover, only little research focuses on studying the German market for indoor vertical farms.

Existing literature revealed primary insights that showed the limited acceptance of large-scale vertical farms. It stated that these are the most difficult to achieve social acceptance with their high level of technological innovation (Specht et al., 2019; Specht, Weith, et al., 2016). This study focused on products grown in commercial large-scale farms and showed contrary results by revealing only little concerns about vertically farmed products and a general positive mindset towards this innovation. Exploratory research and quantitative research proved those outcomes within the study. As a result, consumer attitudes towards vertically farmed greens seem to change.

Moreover, the literature revealed a lack of knowledge about VF and a need for education about urban agriculture, which was underlined by this research and revealed a gap for further research (Grebitus et al., 2017; Jürkenbeck et al., 2019; Perambalam et al., 2021).

The present findings also revealed the perceived sustainability of VF greens as a critical factor influencing consumer attitudes. It highlights the potential disconnection between consumer perceptions and the industry's self-assessment, which is good on the one hand as several studies proved a very limited sustainable approach of the VF industry. On the other hand, sustainability perceptions need to be more closely aligned with the actual situation, which could be investigated in further studies.

Moreover, the study's outcome revealed that the willingness to pay a price premium has a positive effect on consumers' attitudes towards buying VF greens. This complements existing literature by showcasing that consumers will make an extra effort to buy high-quality products (Feldmann & Hamm, 2015; Grebitus et al., 2013). Further research could explore optimal pricing structures within the VF sector.

Overall, the research findings highlight the dynamic nature of consumer perceptions, indicating a potential shift in consumer attitudes towards new innovations within a specific target group. These implications open up incentives for further research, emphasizing the need for an ongoing dialogue between researchers, industry experts, and policymakers.

6.3 Managerial Implications

Besides theoretical implications, this research provides a range of managerial implications. These implications are especially important for indoor VF companies aiming to enter the German market in the future. As the theoretical findings and expert interviews revealed, the German market is not the most attractive for the VF companies at the moment, as it provides good natural conditions for conventional farming and brings high energy and workforce costs. However, results showed a general positive attitude towards VF. At that point, it makes sense to set in, educate people, and drive further technological innovation toward an even more sustainable futuristic farming method. To drive change within the agriculture sector, an adaption of the society towards this innovation is necessary, which was confirmed by the research results. Furthermore, the study primarily included young, urban-living people, who represent the main target group of VF companies. Therefore, these results contribute to a large extent to the understanding of VF barriers and drivers within a highly relevant target group.

The research findings suggest that businesses should focus on a target group that is innovative and open to new products. Even though innovativeness in the context of the product might not be the most crucial, targeted marketing campaigns should aim to reach young and innovation-thriving people. As these target groups are more open-minded, businesses could focus on regular innovations within the market, for example, introducing novel varieties and flavors. This idea was underlined by experts who highlighted the favorable attitudes of their consumers towards extraordinary products (Appendices 3.1 & 3.3).

On the other hand, results also revealed a general lack of knowledge about VF, which may result in insecurities and reserved buying behavior. In an in-depth interview, a consumer stated major concerns about a potential artificial product and highlighted the need for more information about VF. A low average mean within the construct *subjective knowledge about VF* underlines these results. Therefore, it might be important for businesses, maybe in cooperation with the government, to run educational campaigns that shed light upon the processes of VF but also its advantages and disadvantages. In terms of educational messaging, a degree of security and social proof might be necessary to reach and address the Traditionalists. Moreover, these educational messages should not only appeal to consumers' general knowledge about VF but focus on consumers' attitudes and beliefs about sustainable consumption, as the perceived sustainability of VF greens is a crucial factor influencing buying behavior, validated by the findings of this research.

The hypothesis examining the valued attributes within vertically farmed greens revealed healthiness, freshness, high quality, and safety as key attributes triggering the buying behavior of the participants. This goes in line with the qualitative analysis of the consumer interview emphasizing the crucial factor of quality and freshness of vegetables and greens. This outlines a basis for managers and marketers to design efficient marketing communications strategies focusing on these factors, for example, through the transparent communication of the manufacturing process and seals proving the healthy and safe aspect of the products. Furthermore, special packaging, differentiating the products from the conventional ones, might help to raise attention and interest in the new products.

What was emphasized in the customer interviews was that the clarity about the advantages of the VF greens might raise their willingness to pay a price premium. This aspect further underlines the clear communication of outstanding factors of VF greens. Furthermore, it emphasizes that a generally higher willingness to pay exists, what is contrary to expert statements. These research findings could encourage companies to demand a price premium for vertically farmed greens, which might help businesses overcome the main market barriers in the German market. However, exact price ranges and price positioning within the market need further and more detailed investigation.

6.4 Limitations

Despite several valuable insights that sharpen the understanding of VF products, this research also shows its limitations. One potential limitation of this research might be the limited awareness and little subjective knowledge about indoor VF and its products. The descriptive part of this study revealed little knowledge and insecurities about making a purchase within this product segment. Even though a neutral description of VF and its products was included in the customer interview and the quantitative survey, this introduction might have influenced them as attitudes might change when consumers set their own impressions.

Secondly, the study relies on self-reported behavior and attitudes. An actual measurement of behavior, especially in direct comparison to conventional farmed greens, could enhance the study's results and external validity. This fact, coupled with the little knowledge about the product itself, introduces potential discrepancies between stated intentions and actual behavior. Future research could further explore actual buying behavior in the context of VF, a real-world setting that more closely presents the overall decision-making process.
Another limitation might be the non-probabilistic nature of the sample. The primary sample obtained through convenience might not represent a broader population. The fact that the customer interview and the survey were acquired through the researcher's personal network, composed largely of individuals with similar characteristics, might have resulted in a biased sample. Moreover, a broader sample regarding demographics and consumption habits regarding sustainable food could further enhance the study's external validity. Additionally, the conduction of a larger sample could be beneficial to obtain more accurate and significant results. All of these factors compound the generalizability of the results.
Moreover, the findings might hold specific traits within the characteristics of the sample and the study region. As this research focused on young, urban-living people, these people are not necessarily the ones who incorporate many traditionalists, in the sense of people with a low degree of innovativeness. Therefore, this might present another bias.

6.5 Future Research

The literature review did not reveal a single study with the approach of visual testing within the VF industry. Even though a picture of a diverse range of VF greens was included in the online survey to stimulate the participant's imagination, further visual testing on the physical package design might enhance research findings since most of the participants did not buy a VF green before or at least do not know exactly. Furthermore, field experiments could deliver more valuable insights into consumers' behavioral attitudes.
Several studies, including this study, focused on a particular market (Grebitus et al., 2017; Perambalam et al., 2021; Specht, Siebert, et al., 2016). An analysis between different countries could offer a cross-cultural comparison of the different consumer perceptions of VF. Expert interviews revealed a current industry focus on countries that do not offer good natural conditions for conventional farming methods. This could bring up valuable insights into the market demand within other markets (Appendices 3.1 & 3.2).

On top of that, future research could investigate a more detailed potential market positioning for indoor VF greens. As this research revealed the potential to target young, innovative, open-minded people, this could be further investigated, defining more specific target personas for companies.

Time restrictions did not allow this research to measure changing attitudes and behavior over time. As previous literature already emphasized the changing consumer attitudes, especially in regard to COVID-19, but also the increasing awareness of the ecological footprint, it could be interesting to investigate how attitude and acceptance change over time (McMichael et al., 2007; Moghimi, 2021; Specht et al., 2019). As VF will gain more popularity in the near future, it is interesting to focus future research on this aspect.

7 Conclusion

Even though the German vegetable market does not rely on vertically farmed products at the moment, that might be the case in the near future. This thesis reveals that individuals, especially young people with an innovative mindset, in general, have a positive standing towards vertically farming greens, but still, there are concerns and a conditional willingness to pay. Therefore, it is crucial to educate the consumers about it, make it appealing and attractive, and drive the technological innovation process even faster. The innovative concept of urban agriculture through VF systems holds great promise in terms of efficiency and sustainability. Thrive change in the market towards more sustainable innovations is crucial to overcome the barriers VF is facing at the moment.

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Appendix

Appendix 1 – Explanation of Different Agriculture Techniques

Hydroponics, a soilless plant cultivation method, is highly resource-efficient and reduces the need for pesticides, making it the predominant growing system in vertical farms (Perambalam et al., 2021). In hydroponic systems, plants are anchored in inert growing media like cocopeat and nourished by a nutrient-rich water solution. Alternatively, the roots are directly bathed in the nutrient liquid using the nutrient-film technique(Maurya et al., 2023). This method offers the advantage of utilizing approximately 70% less water than traditional farming practices as is reuses any water and nutrients that does not get absorbed by the by the roots direclty (Benke & Tomkins, 2018; Pavithra, 2018). This farming method is especially well-fitted for vegetables like spinach and tomatoes and berries (Despommier, 2009).

In contrast, **aeroponics** is a relatively novel technique that grows plants in the air. The hanging roots are sprayed with a nutrient-rich water solution in the form of an atomized mist. Aeroponics uses even less water than the hydroponic system and does not require the use of pesticides or fertilizers (Benke & Tomkins, 2018; Maurya et al., 2023; Pavithra, 2018).Furthermore, aeroponics enables the absorption of more minerals and vitamins than hydroponic planted plants, ensuring healthier and nutrient-rich plants (Khandaker & Kotzen, 2018). It is especially good for root crops like potatoes and carrots (Despommier, 2009). However, VF systems come with not only benefits but also different kind of challenges, which will be further examined in the next part.

Finally, **aquaponics** is a system that combines aquaculture, or fish farming, on the lower levels with hydroponics, which grows plants in water without soil. It takes advantage of the symbiotic relationship between fish and soilless plant production (He, 2017; Maurya et al., 2023). In this way, nutrient-rich effluent is used to fertilize horticultural crops, and the majority of the nutrients that maintain optimal plant growth are derived from the waste from feeding aquatic organisms (Palm et al., 2018; Specht et al., 2019). It is often highlighted as one of the technologies that could change our lives by producing protein in urban farms, but there are also major concerns about the economic and environmental sustainability of these systems (O'Sullivan et al., 2019).

Appendix 2 – Expert Interview Guideline

Introduction:

Hi! First of all, thank you for participating in this short expert interview on VF for my Master Thesis on behalf of Católica Lisbon! The goal of this interview is to create a more critical point of view around the topics of VF in the German market and like that gain real insights into the industry itself. It's going to take about 20 minutes. Please answer freely. All information is welcome, so if you feel like sharing anything beyond my questions, please do so.

Two last questions from my side before we are going to start:

- Would it be okay if I audio recorded this entire interview?
- Would you like to be referenced in my thesis with your name and professional path or would you prefer to remain anonymous?

And questions from your side? If not, maybe you can start by introducing yourself and after that I would start with my questions.

Interview Questions:

1. How would you describe the VF market in Germany compared to the global market?
2. Out of your point of view, what are the main drivers of interest and growth in the German VF market?
3. What are the major reasons for the slow growth or failure of VF companies in Germany out of your point of view? What challenges are German companies facing right now?
4. Would you define VF as sustainable? And what role does sustainability and environmental concerns play in the development of VF in Germany?
5. As you are working for a VF company in Germany, what is your target group right now and could you explain the reasons for that a bit further?
6. What are the key factors influencing consumer perception and acceptance of vertical farmed products?
7. What do you think is needed in order to shift the people's mindset towards indoor grown vegetables and fruits?
8. In your opinion, when will VF become an essential part of the German agricultural market?

Outro:

Anything you want to add / comment or any final thoughts? Otherwise, thank you so much for participating and have a great day!

Appendix 3 – Expert Interview Summary

Appendix 3.1 - Expert Interview No. 1

Name: Anonymous

Description: The anonymous interviewee works as Strategy and Business Development Manager for a European VF Company and has two years of working experience in the VF industry.

Date and Length of Interview: 09.11.2023; 30 minutes

Question	Summary of Expert Answer
1	- In general drivers for VF are the mass of imported vegetables within a country and based on that also the conventional farmed vegetable mass; demand; willingness-to-pay - Germany might not be the biggest market for VF. The Netherlands are the biggest export market in Europa and exports a lot to German (mass market makes all kind of vegetables very cheap). - No mass market in Germany, focus on small companies selling microgreens or focusing on premium segment like restaurants. Niche market with cool branding etc. could work. - To add: No bio certification possible for VF products in Germany because the VF products are not grown on proper ground. - Mideast and Scandinavian are way bigger markets for successful VF as they show bad natural cultivation conditions. - One could focus on the premium segment in the Netherlands for example where they sell directly to restaurants and hotels. There it's about the taste and the quality of the product but also a diversity of products and new tastes (e.g. wasabi microgreens).
2	Drivers of VF in general: - Bad cultivation conditions within the country itself e.g. Saudi Arabian - Serving the mass market for low unit price - Low energy costs within a country

	- Island could be a great market, besides the small number of populations, as they can provide cheap, sustainable energy and have to pay a lot of transportation costs for exported goods. Factors that will drive the growth of VF in the future: - Decreasing LED prices - Decreasing electricity costs and potential for renewable energy - R&D to let the crops grow faster
3	Main challenges: - High electricity costs -Companies are advertising new technology methods, huge indoor farms, automatization etc. but in the end, it might not be the most profitable business model. It needs to be differentiated and maybe it just does not make sense to build huge vertical farms within Germany.
4	- Most important to make the VF business sustainable is to source the electricity in a sustainable way (at the moment reenable energy is too expensive; renewable energy needed). - Main factors: way less water needed than conventional farming and no pesticides
5	/
6	- Did not experience any problems of consumer acceptance so far. - Consumer Feedback: They enjoy and appreciate the taste of the products but also the freshness of the product, you do not even have to wash the product. - In general, good perception. Therefore, this might not become a barrier
7	- No needed mindset shifts - What is needed are lower prices of the products or a key differentiating factor like innovativeness or quality
8	At the point of time where the key exporter of the German vegetable market (e.g. Spain and Italy) are not able to export anymore, for several reasons like ground quality, water supply etc., VF may become attractive in the German market.

Appendix 3.2 - Expert Interview No. 2

Name: Stefano Augstburger

Description: Stefano Augstburger is Co-CEO and Chairman at YASAI AG and has five years of working experience in the VF industry. YASAI is a circular VF company based in Switzerland. They focus on healthy, fresh, and locally grown herbs and leafy greens. Their farms are highly automated and run by AI. They focus on herbs right now as these are the most profitable.

Date & Length of Interview: 14.11.2023; 30 minutes

Question	Summary of Expert Answer
1	- Germany is not an attractive market because of the high prices for groceries, the low willingness to pay for food and high energy prices not only in Germany but also in the Netherlands. - Switzerland is an attractive market as people value high quality and local products and pay a lot for groceries in general. Scandinavian might also be an attractive market with regard on their renewable energy sources. - Flagship company is Bowery in New York (https://bowery.co/).
2	Drivers: - Willingness to pay for food / groceries. - Energy prices
3	- High interest rates at the moment and that's the pain point for CAPEX intense projects. As VF needs quite high investments this might be the main reason, but it needs high investments to be able to automize the processes but also to grow a variety of products within the farms. - But also, high energy costs.
4	- Most important are renewable energies but too expensive right now. - Revolutionizing the market does not allow a strong focus on sustainability right now.
5	- Somewhere within the price range of local and biological products. - People that value the quality of the products.

	- Most important: Product should not be more expensive than comparable products.
6	- Showing locally grown on their products (Switzerland) but also without pesticides, save water etc. - In general, a lot of good feedback from customers even though some people claim it as too artificial.
7	- The customer's mindset is not the problem it's more about the prices and to stay competitive in the market.
8	- Technological development - Salads, berries, and other products need higher investments but also technological development in the future. - Energy prices need to go down

Appendix 3.3 - Expert Interview No. 3

Name: Maik Brinkkötter

Description: Maik Brinkkötter is the former Director of VF at Miele and current Director at Agrilution, with three years of working experience in the VF industry. Miele is a German manufacturer known for producing high-end household equipment, particularly kitchen and laundry appliances. By acquiring the Munich-based start-up company Agrilution, Miele has further strengthened its commitment to promoting diverse cuisine and healthy living. Their Plantcube, a fully automated cultivation cabinet, allows for daily harvests of fresh salads, herbs, and microgreens at home, offering an elegant kitchen solution catering to the needs of a small family. Recently, the company announced that it will discontinue Agrilution due to a lack of economic perspective.

Date & Length of Interview: 17.11.202; 30 minutes

Question	Summary of Expert Answer
1	- Companies are emerging in the market with a focus on systems that allow the growth of plants at home, on the window board, rather than integrated systems. - The topic of VF has greatly benefited from the current sustainability debate. - North America and Asia present attractive markets due to the lower availability of fresh vegetables and fruits in these countries.

2	Positive drivers: sustainability, healthy diet, DIY and home-grown vegetables, health Negative drivers: electricity costs, initial set up costs for the systems
3	- Lack of demand - High initial costs - In the end, VF is simply a hobby, as these types of small-scale systems are insufficient for achieving a fully balanced diet that meets all vegetable requirements.
4	- Sustainability is one of the main drivers for VF - The sustainability of VF is currently not viable, particularly in the case of small systems, due to the significant resources required for hardware construction and energy consumption during device operation, as well as the disposal of the product. The product's overall lifespan is not sustainable. - But in general, the concept behind VF aligns with a sustainable approach, indicating a step in the right direction.
5	Persona 1: Young, sporty, values a healthy diet, self-improvement Persona 2: Sustainability (operational phase of these systems can be described as sustainable) Persona 3: People that are driven by new innovations of any kind In general people that value an optic appealing product within their home.
6	- In general, there is a big difference between large-scale products and home-grown ones: - Large-scale farms are a black box as people do not see what exactly happens within these systems, how the plant really gets cultivated and so on. - In contrast, small home farms allow people to see how the plant grows and that no pesticides are used. The exceptional taste, variety, cleanliness, and freshness of the products also attract consumers.
7	- Habits must change, particularly in this case, requiring a drastic situation to prompt such a shift (e.g. people experience the consequences of climate warming).
8	- Traditional farmers are very critical towards these models - Politics are critical as well and protect the traditional farming methods

	- The home growing VF models might become an integrated model in homes quite fast - But the large-scale might take some time

Appendix 4 - Consumer Interview Guideline

Introduction: Hi! First of all, thank you for participating in this short interview on VF for my Master Thesis on behalf of Católica Lisbon! The goal of this interviews is to gain a general understanding of your awareness you're your perception of various topics around VF. It's going to take about 25 minutes. Please answer freely. All information is welcome, so if you feel like sharing anything beyond my questions, please do so. Two last questions from my side before we are going to start: Would it be okay if I audio recorded this entire interview? And questions from your side? If not, maybe you can start by introducing yourself.

Interview Questions:

1. Are you interested in new innovations in the food market, and do you enjoy trying new foods?
2. What do you know about the concept of VF? And what associations come to your mind thinking about "VF"?

Introduction: Even if you have some understanding of VF, please pay attention to learn about commercial vertical farms and the growth of vertical farmed greens such as leafy salad and herbs. In VF, kitchen herbs and salads are grown in warehouses located near urban centers. Plants are cultivated in a controlled environment enabling year-round production. This process uses up to 95% less water than conventional methods thanks to water reuse and more precise watering. LED lights support plant growth. Since production and sales occur in the same city, the transportation distance is usually short. The crops thrive on an absorbent substrate, with their roots suspended in a solution containing all necessary nutrients. This type of agriculture doesn't require the use of pesticides. There are some requirements for growing crops commercially in indoor vertical farms using artificial light. Therefore, this research will focus on vertically farmed greens such as herbs and leafy salad.

3. What product attributes would be important to you when purchasing vertically farmed greens?
4. Are there any concerns or reservations you have about consuming vertically farmed products?

5. Are sustainability considerations a factor in your food choices?
6. Do you consider VF to be a sustainable form of agriculture? Which aspects do you consider most / least sustainable?
7. How likely is it that you would consider vertically farmed greens when buying your greens in your supermarket? And what might influence your decision to choose indoor vertically farmed greens over traditional alternatives?
8. Would you be willing to pay more for a vertical farmed green than a conventional farmed one?
Outro: Anything you want to add / comment or any final thoughts? Otherwise, thank you so much for participating and have a great day!

Appendix 5 – Consumer Interview Summary and Thematic Analysis

Appendix 5.1 Summary

Question	Summary of Consumers Answers
1	- All participants stated to be interested in new innovations in the food market. - e.g. I love trying new things when it comes to food
2	- I don’t know a lot about it but I imagine it to be super-efficient in multiple ways like space wise. What I associate with it is self-supporting, like our parents did with the homegrown tomatoes. But I can also imagine it on a much bigger scale since it seems quite efficient to me. - It can be very sustainable and fully controlled. - I am familiar with the concept of VF but have little deeper knowledge. In my understanding it describes the idea of developing indoor farms, mostly for urban areas that are vertically built to be very efficient in using limited space. Vertical farms are quite high-tech using e.g. automated water system and lighting systems for optimization of productivity of farms. My first association with VF is that it is the future of farming as it enables local production with very efficient processes eliminating cost of transportation and bringing production to the people. - You plant the plants vertical to have more to harvest, since you are able to fit more plants in less space. - My direct associations are: AI, sustainable farming and sensors.

	- I find the concept very fascinating and think it could be very relevant for the future. Especially if it is possible to grow crops even more effectively and sustainably. I always have to think of high-tech buildings where perfect vegetables grow that are safe from any pests and therefore don't need to be sprayed with chemicals. - I don't know anything about it. - The only thing I know is that it aims to optimize plant growth and that it is more expensive in the supermarkets.
3	- Taste, maybe color but not necessarily, no chemicals used - Sustainability, less water use, modern concept - Freshness, color, taste - No pesticides used, good quality - Fresh, sustainable, tasty - Healthy, high quality, sustainable, availability and price - A good taste and fair prices - Freshness, quality and taste, price, sustainability, local support, convenience, local support, packaging - Not harmful and do not contain the same nutrients as conventionally products
4	- Because you are not used to it, I think most people imagine it to be rather unnatural and harmful, even though it might be better. - Energy use, limited variety, nutritional level - Exhaust gums from the environment could have a negative impact on the quality of the products. - No not really! I like the idea to grow herbs and salads near the consumer - Will they get all the vitamins and nutrients without actual sunlight but artificial light sources?
5	Most of the participants stated that sustainable considerations are a factor in their food choices. - e.g. Yes. Not always, but I’m trying. - e.g. Yes! I try to be sustainable but convince is more important. Means if I they do not have sustainable options available I still buy them. - e.g. Sometimes, but just for some products.

6	- I consider the concept as sustainable! For me the short supply and the reduced water are positive main factors about this concept. - Most sustainable is the optimized water usage, the abandonment of pesticides and cutting transportation distances. I don't see any parts that are less sustainable relative to conventional production. - Yes, I do. The small distance to the sales point is a big plus and to fit more plants in less space. A less sustainable aspects is the use of led lights instead of natural sunlight. - Yes, I think it is sustainable. Water saving is very important in the future. - Yes, I think it can be, but it depends. If for some corps a lot of heating or cooling or lots of energy is required, it will not be as good as local produced goods. - Vertical framing appears to be very sustainable because the products are grown regionally and are more environmentally friendly due to the lower water consumption and the absence of chemical agents. However, the question arises as to whether LED lighting for plants is sustainable in the long term. - Most sustainable out of my point of view is the water efficiency, reduced land use. The least sustainable might be the high energy consumption, initial infrastructure cost.
7	- Would 100% consider and definitely try. What might trigger a bad conscience: the lack of work for farmers that do have farms are not willing to/not able to switch to VF because they maybe don’t have the money and/or resources. - I would consider buying it. For me the taste, the sustainable production and price are factors which influence my buying behavior. - Very likely. For me it is the better way to produce greens. Our agriculture is systemically destroying the planet and we have very limited resources and production capacities for food. VF as part of an optimized production could solve this problem lowering emissions, usage of pesticide and especially destruction of land due to monocultures etc. Therefore, I see VF as a great alternative which is not in any way more artificial than traditional alternatives. - I would try it. However, price and quality would be a big factor for me. If it’s way more expensive than traditional alternatives i would probably stick with these.

	- I would need more information around the whole topic and some convincing why it is better. It would for example be interesting to see how much more sustainable it is compared to other products in the market. And of course, the price difference can't be too big. - I would choose vertical framed green because it is very important for me to use the more sustainable option. If the price is not significantly higher than that of traditional alternatives, then there are no longer any reasons for me to choose the more environmentally harmful product. - I think I tend to not consider these products. But here are reasons why I would consider/would not consider: Likely consider: Freshness, taste, sustainability. Not consider: Limited availability, significantly higher price. - I would consider the products. But I think you need to get used to the idea first, as it is not familiar, and I think anything unfamiliar or not naturally occurring might be initially associated with something negative. The question is also how the products are recognizable, in terms of packaging.
8	5 out of 9 participants stated to be willing to pay even more. - e.g. I would be willing to pay equal the amount. Since there's less usage of water and way shorter ways of transport it shouldn't be much more expensive in my mind. - e.g. Right now no but if I have more money in the future and the quality is better than definitely yes! - e.g. I would pay more if it is significantly more sustainable or healthier.

Appendix 5.2 – Thematic Analysis

Category	Codes	Theme
Interest in Food, Innovations and New Foods	- General interest in new food innovations - Adventurous taste	Positive attitudes towards innovation
Knowledge about VF and Associations	- Efficiency and sustainability - Technology and future - Mixed knowledge levels	Varied knowledge
Relevant Product Attributes	- Sustainability - Quality and taste - Health considerations	Key attributes in purchase decision
Concerns and Reservations about VF	- Skepticism about naturalness - Environmental impact - General positive outlook	Uncertainty
Daily Sustainability Considerations	- Conscious food choices - Confronted with trade-offs (convenience and availability)	Sustainability as an important factor
Sustainability Perceptions of VF	- Water efficiency - Reduced land use - Different concerns	Positive image of the sustainability of VF
Likelihood to choose VF Greens	- General openness to VF - Influencing factors: - taste - sustainability - price - Information and familiarity	Positive consideration with conditions
Willingness to pay Price Premium	- Mixed willingness to pay high price - Conditions: - sustainability - health benefits - financial capability	Mixed willingness to pay premium

Appendix 6 – Survey Structure

Introduction

Hello and thank you for participating in this survey! This online survey is conducted as part of my Master's Thesis in New Product Innovation at Católica Lisbon. The survey aims to assess individuals' perception and acceptance of VF. Your participation is very important to me and entirely voluntary. The survey is anonymous, and data collected will be kept strictly confidential. This survey will take approximately 5 minutes to complete. If you are willing to provide your insights, consent in the next step. Please do not hesitate to contact s-lessmann@ucp.pt if you have any questions or comments about this study.

Screening Questions

1) Do you live in Germany?

Yes | No (→ END OF SURVEY)

2) In which city do you live?

Berlin | Bremen | Cologne | Düsseldorf | Frankfurt | Hamburg | Hannover | Munich | Stuttgart | Other:

3) How old are you?

Under 18 years old (→ END OF SURVEY) | 18 – 24 years old | 25 – 32years old | 33 – 40 years old | + 40 years old

Consumer Food Tech Innovativeness & Attitude Towards Sustainability in the Food Sector

4) The first part of this survey is about your interest in innovation in the food sector. Therefore, please choose the statement you identify the most with.

- I am someone who keeps up with new advances in food technology and takes risks by being the first to buy an innovative food product, regardless of what function it is performing.
- I am someone who wants to see the benefits of new ideas in the food sector and then be one of the first to make use of them.
- I am someone interested in new food products, but my decisions are largely influenced by the suggestions made by current users who fully tested the product.

- I prefer safe food options to exciting new products in the food industry. For me to consider an innovative food product, it must have been on the market for some time and have a clear benefit.
- I prefer traditional food and I am not interested in trying innovative food products. I do not enjoy changes in life and I only buy an innovative food product when the existing model I use is no longer available.

5) Now it's about your interest in sustainability in the food sector. Therefore, please indicate your level of agreement with the following statements. *Scale: 5-point Likert Scale from Strongly Agree to Strongly Disagree*

- The sustainability of food has a big impact on my food choices.
- I care a lot about the sustainability of food.
- A healthy diet is important to me.
- I always eat food with a sustainable background.
- The sustainability of snacks makes a difference to me.
- I avoid food that is not sustainable.

<u>Subjective Knowledge about VF</u>

Introduction: We are interested to get to know more about your knowledge about the concept of VF, an approach to grow vegetables and fruits within urban areas. No worries if you don't know anything by now but please just state honestly.

6) Have you ever bought a product grown in a Vertical Farm?

Yes | No | I don't know

7) Please rate your agreement with the following statements regarding your knowledge about VF. *Scale: 5-point Likert Scale from Strongly Agree to Strongly Disagree*

- I am familiar with the concept of VF.
- I know how to judge the quality of a vertical farmed greens.
- I think I know enough about vertical farmed greens to feel pretty confident when I make a purchase.
- I do feel very knowledgeable about VF.
- Compared to most other people, I know a lot about VF.

- When it comes to VF, I really do know a lot.
- I can tell if a vertical farmed green is worth the price or not.

Attitudes Towards VF Greens and Perceived Sustainability of VF Greens

Introduction Vertical Farming

Vertical Farms: In VF, kitchen herbs and salads are grown in warehouses located near urban centers. Plants are cultivated in a controlled environment enabling year-round production. This process uses up to 95% less water than conventional methods thanks to water reuse and more precise watering. LED lights support plant growth. Since production and sales occur in the same city, the transportation distance is usually short. The crops thrive on an absorbent substrate, with their roots suspended in a solution containing all necessary nutrients. This type of agriculture doesn't require the use of pesticides. **Vertical Farmed Greens:** There are some requirements for growing crops commercially in indoor vertical farms using artificial light. Therefore, this research will focus on vertically farmed greens such as herbs and leafy greens.

8) Please rate your agreement with the following statements regarding your attitude towards vertical farmed greens. *Scale: 5-point Likert Scale from Strongly Agree to Strongly Disagree*

- I think vertically farmed greens are **innovative**.
- I think vertically farmed greens are **healthy**.
- I think vertically farmed greens are **fresh**.
- I think vertically farmed greens are **tasty**.
- I think vertically farmed greens are **safe**.
- I think vertically farmed greens are **artificial**.
- I think vertically farmed greens are **nutritious**.
- I think vertically farmed greens are high quality products.

- I think vertically farmed greens are **worth to pay more** for than conventional farmed greens.

9) Please rate your agreement with the following statements regarding your attitude towards the sustainability of vertical farmed greens. *Scale: 5-point Likert Scale from Strongly Agree to Strongly Disagree*

- I think vertical farmed greens come **from close by**.
- I think vertical farmed greens are a **local product**.
- I think vertical farmed greens produce **minimal CO2 emissions**.
- I think vertical farmed greens are produced **without disturbing the balance of nature**.
- I think vertically farmed greens are produced in an **environmentally friendly** way.
- I think the production of vertically farmed greens **conserves resources** like water.
- Please select Strongly Disagree. *(Control Question)*

10) Please rate your agreement with the following statements regarding your attitude towards buying a vertical farmed green. *Scale: 5-point Likert Scale from Strongly Agree to Strongly Disagree*

- I am positive towards a purchase of vertically farmed greens.
- I am likely to buy a vertically farmed green if it is available at my local supermarket.
- I would like to try a vertically farmed green.

11) Would you be willing to pay a price premium for vertically farmed greens?

- Yes
- No

<u>Demographics</u>

12) What gender do you identify with?

Male | Female | Non-binary / third gender | Prefer not to say

13) What is your highest level of education?

No Formal Education | Secondary Education | Bachelor's Degree | Master's Degree | Doctorate or Professional Degree

14) What is your current main occupation?

Student without a Job | Student with a Job | Full-time Job | Part-time Job | Unemployed | Retired | Other

15) What was your total household income before taxes during the past 12 months in Euros?

Less than 25,000 € per year | 25,000 - 49,999 € per year | 50,000 - 99,999 € per year | 100,000 - 199,999 € per year | More than 200,000 € per year | Prefer not to say

Appendix 7 – Sample Statistics

Gender		Frequency	Percent	Valid Percent	Cumulative %
Valid	Male	45	34.1	34.1	34.1
	Female	87	65.9	65.9	100.0
	Total	132	100.0	100.0	

Age		Frequency	Percent	Valid Percent	Cumulative %
Valid	18 – 24 years old	28	21.2	21.2	21.2
	25 – 32 years old	84	63.6	63.6	84.8
	33 – 40 years old	7	5.3	5.3	90.2
	+ 40 years old	13	9.8	9.8	100.0
	Total	132	100.0	100.0	

Education		Frequency	Percent	Valid Percent	Cumulative %
Valid	No Formal Education	2	1.5	1.5	1.5
	Secondary Education	16	12.1	12.1	13.6
	Bachelor's Degree	69	52.3	52.3	65.9
	Master's Degree	42	31.8	31.8	97.7
	Doctorate or Professional Degree	3	2.3	2.3	100.0
	Total	132	100.0	100.0	

Occupation		Frequency	Percent	Valid Percent	Cumulative %
Valid	Student without a Job	15	11.4	11.4	11.4
	Student with a Job	29	22.0	22.0	33.3
	Full-time Job	75	56.8	56.8	90.2
	Part-time Job	3	2.3	2.3	92.4
	Unemployed	1	.8	.8	93.2
	Retired	4	3.0	3.0	96.2
	Other	5	3.8	3.8	100.0
	Total	132	100.0	100.0	

Income before taxes		Frequency	Percent	Valid Percent	Cumulative %
Valid	Less than 25,000 € per year	36	27.3	27.3	27.3
	25,000 - 49,999 € per year	32	24.2	24.2	51.5
	50,000 - 99,999 € per year	42	31.8	31.8	83.3
	100,000 - 199,999 € per year	15	11.4	11.4	94.7
	More than 200,000 € per year	2	1.5	1.5	96.2
	Prefer not to say	5	3.8	3.8	100.0
	Total	132	100.0	100.0	

Home City		Frequency	Percent	Valid Percent	Cumulative %
Valid	Berlin	16	12.1	12.1	12.1
	Bremen	18	13.6	13.6	25.8
	Cologne	6	4.5	4.5	30.3
	Düsseldorf	2	1.5	1.5	31.8
	Frankfurt	5	3.8	3.8	35.6
	Hamburg	55	41.7	41.7	77.3
	Hannover	2	1.5	1.5	78.8
	Munich	9	6.8	6.8	85.6
	Stuttgart	6	4.5	4.5	90.2
	Somewhere else:	13	9.8	9.8	100.0
	Total	132	100.0	100.0	

Appendix 8 – Sample Frequencies

Innovator Type		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Innovators	22	16.7	16.7	16.7
	Early Adopters	39	29.5	29.5	46.2
	Early Majority	44	33.3	33.3	79.5
	Late Majority	23	17.4	17.4	97.0
	Traditionalists	4	3.0	3.0	100.0
	Total	132	100.0	100.0	

Ever Bought VF Product Before		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	17	12.9	12.9	12.9
	No	49	37.1	37.1	50.0
	I don’t know	66	50.0	50.0	100.0
	Total	132	100.0	100.0	

Willingness To Pay Price Premium		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	73	55.3	55.3	55.3
	No	59	44.7	44.7	100.0
	Total	132	100.0	100.0	

Appendix 9 – Descriptive Statistics

Tests of Normality	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Q5. Attitude towards Food Sustainability	.080	132	.037	.981	132	.056
Q7. Subjective Knowledge of VF	.075	132	.069	.971	132	.006
Q8. Attitudes towards VF Greens	.078	132	.048	.985	132	.147
Q9. Perceived Sustainability of VF Greens	.142	132	< .001	.956	132	< .001
Q10. Attitude towards Buying VF Greens	.182	132	< .001	.874	132	< .001

a. Lilliefors Significance Correction

One-Sample Statistics	N	Mean	Std. Deviation	Std. Error Mean
Q5. Attitude towards Food Sustainability	132	3.4230	.76012	.06616
Q7. Subjective Knowledge of VF	132	2.4798	.91543	.07968
Q8. Attitudes towards VF Greens	132	3.9574	.50542	.04399
Q9. Perceived Sustainability of VF Greens	132	3.8636	.64219	.05590
Q10. Attitude towards Buying VF Greens	132	4.1439	.75743	.06593

	Test Value = 3						
			Significance			95% Confidence Interval of the Difference	
One-Sample Test	t	df	One-Sided p	Two-Sided p	Mean Difference	Lower	Upper
Q5. Attitude towards Food Sustainability	6.393	131	< .001	< .001	.42298	.2921	.5539
Q7. Subjective Knowledge of VF	-6.529	131	< .001	< .001	-.52020	-.6778	-.3626
Q8. Attitudes towards VF Greens	21.763	131	< .001	< .001	.95739	.8704	1.0444
Q9. Perceived Sustainability of VF Greens	15.451	131	< .001	< .001	.86364	.7531	.9742
Q10. Attitude towards Buying VF Greens	17.352	131	< .001	< .001	1.14394	1.0135	1.2744

Appendix 10– Internal Consistency and Scale Reliability

Constructs and Items	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**	**Cronbach's Alpha (N=132)**
Q5. Attitudes Towards Food Sustainability (6 items)			**0.879**
The sustainability of food has a big impact on my food choices.	.803	.840	
I care a lot about the sustainability of food.	.767	.845	
A healthy diet is important to me.	.452	.892	
I always eat food with a sustainable background.	.725	.852	
The sustainability of snacks makes a difference to me.	.734	.850	
I avoid food that is not sustainable.	.655	.866	

Q7. Subjective Knowledge of VF (6 items)			**0.909**
I am familiar with the concept of vertical farming.	.659	.908	
I know how to judge the quality of vertical farmed greens.	.780	.890	
I feel very confident when I purchase vertical farmed greens.	.682	.902	
I do feel very knowledgeable about vertical farming.	,819	.883	
Compared to most other people, I know a lot about vertical farming.	.802	.885	
I can tell if a vertical farmed green is worth the price or not.	.767	.890	
Q8. Attitudes Towards VF Greens (9 items)			0.806
I think vertically farmed greens are artificial (INV).	.262	.834	
Q8. Attitudes Towards VF Greens (8 final items)			**0.834**
I think vertically farmed greens are innovative.	.448	.829	
I think vertically farmed greens are healthy.	.713	.794	
I think vertically farmed greens are fresh.	.668	.802	
I think vertically farmed greens are tasty.	.618	.808	
I think vertically farmed greens are safe.	.695	.799	
I think vertically farmed greens are nutritious.	.624	.811	
I think vertically farmed greens are high quality.	.604	.809	
I think vertically farmed greens are worth paying more for than conventionally farmed greens.	.331	.865	
Q9. Perceived Sustainability of VF Greens (6 items)			0.764
I think vertical farmed greens come from near where I live.	.244	.802	
Q9. Perceived Sustainability of VF Greens (5 final items)			**0.802**
I think vertical farmed greens are a local product.	.341	.838	
I think vertical farmed greens produce minimal CO2 emissions.	.628	.751	
I think vertical farmed greens are produced without disturbing the balance of nature.	.685	.730	
I think vertically farmed greens are produced in an environmentally friendly way.	.770	.708	
I think the production of vertically farmed greens conserves resources like water.	.544	.776	
Q10. Attitudes Towards Buying VF Greens (3 items)			**0.889**
I am positive towards a purchase of vertically farmed greens.	.792	.834	
I am likely to buy a vertically farmed green if it is Available at my local supermarket.	.801	.827	
I would like to try a vertically farmed green.	.759	.862	

Appendix 11 - Kruskal-Wallis Test

Ranks	Innovator type	N	Mean Rank
Q10. Attitude towards Buying VF Greens	Innovators	22	94.02
	Early Adopters	39	77.53
	Early Majority	44	53.02
	Late Majority	23	54.74
	Traditionalists	4	23.50
	Total	132	

Test Statistics[a,b]	Q10. Attitude towards Buying VF Greens
Kruskal-Wallis H	28.273
df	4
Asymp. Sig.	< .001
Exact Sig.	.[c]
Point Probability	.

a. Kruskal Wallis Test
b. Grouping variable: Innovator type
c. Numerical difficulties prevented calculation

Pairwise Comparisons of Innovator type Sample 1- Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Traditionalists-Early Majority	29.523	19,.637	1.503	.133	1.000
Traditionalists-Late Majority	31.239	20.370	1.534	.125	1.000
Traditionalists-Early Adopters	54.026	19.742	2.737	.006	.062
Traditionalists-Innovators	70.523	20.439	3.450	< .001	.006
Early Majority-Late Majority	-1.716	9.675	-.177	.859	1.000
Early Majority-Early Adopters	24.503	8.270	2.963	.003	.030
Early Majority-Innovators	41.000	9.819	4.176	< .001	.000
Late Majority-Early Adopters	22.787	9.886	2.305	.021	.212
Late Majority-Innovators	39.284	11.214	3.503	< .001	.005
Early Adopters-Innovators	16.497	10.026	1.645	.100	.999

Asymptotic significances (2-sided tests) are displayed. The significance level is .050
a. Significance values have been adjusted by the Bonferroni correction for multiple tests

Tests of Normality		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Innovator type	Statistic	df	Sig.	Statistic	df	Sig.
Q10.Attitude Towards Buying VF Greens	Innovators	.280	22	< .001	.782	22	< .001
	Early Adopters	.185	39	.002	.819	39	< .001
	Early Majority	.168	44	.003	.929	44	.010
	Late Majority	.220	23	.005	.881	23	.010
	Traditionalists	.402	4	.	.753	4	.041

a. Lilliefors Significance Correction

Test of Homogeneity of Variance		Levene Statistic	df1	df2	Sig.
Q10.Attitude towards Buying VF Greens	Based on Mean	4.757	4	127	.001
	Based on Median	3.093	4	127	.018
	Based on Median and with adjusted df	3.093	4	74.821	.021
	Based on trimmed mean	4.447	4	127	.002

Appendix 12 – Correlation Matrix

Correlations

		Q5.Attitude towards Food Sustainability	Q7.Subjective Knowledge of VF	Q8.Attitudes towards VF Greens	Q9.Percieved Sustainability of VF Greens	Q10.Attitude towards Buying VF Greens
Q5.Attitude towards Food Sustainability	Pearson Correlation	1	,474**	,454**	,336**	,520**
	Sig. (2-tailed)		<,001	<,001	<,001	<,001
	N	132	132	132	132	132
Q7.Subjective Knowledge of VF	Pearson Correlation	,474**	1	,584**	,374**	,515**
	Sig. (2-tailed)	<,001		<,001	<,001	<,001
	N	132	132	132	132	132
Q8.Attitudes towards VF Greens	Pearson Correlation	,454**	,584**	1	,655**	,696**
	Sig. (2-tailed)	<,001	<,001		<,001	<,001
	N	132	132	132	132	132
Q9.Percieved Sustainability of VF Greens	Pearson Correlation	,336**	,374**	,655**	1	,636**
	Sig. (2-tailed)	<,001	<,001	<,001		<,001
	N	132	132	132	132	132
Q10.Attitude towards Buying VF Greens	Pearson Correlation	,520**	,515**	,696**	,636**	1
	Sig. (2-tailed)	<,001	<,001	<,001	<,001	
	N	132	132	132	132	132

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			Q10.Attitude towards Buying VF Greens
Spearman's rho	I think vertically farmed greens are innovative.	Correlation Coefficient	,454**
		Sig. (2-tailed)	<,001
		N	132
	I think vertically farmed greens are healthy.	Correlation Coefficient	,631**
		Sig. (2-tailed)	<,001
		N	132
	I think vertically farmed greens are fresh.	Correlation Coefficient	,553**
		Sig. (2-tailed)	<,001
		N	132
	I think vertically farmed greens are tasty.	Correlation Coefficient	,370**
		Sig. (2-tailed)	<,001
		N	132
	I think vertically farmed greens are safe.	Correlation Coefficient	,524**
		Sig. (2-tailed)	<,001
		N	132
	I think vertically farmed greens are artificial.	Correlation Coefficient	-,339**
		Sig. (2-tailed)	<,001
		N	132
	I think vertically farmed greens are nutritious.	Correlation Coefficient	,431**
		Sig. (2-tailed)	<,001
		N	132
	I think vertically farmed greens are high quality.	Correlation Coefficient	,446**
		Sig. (2-tailed)	<,001
		N	132
	I think vertically farmed greens are worth paying more for than conventionally farmed greens.	Correlation Coefficient	,350**
		Sig. (2-tailed)	<,001
		N	132

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 13 – Linear Regression Analysis

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Q5.Attitude towards Food Sustainability[b]	.	Enter

a. Dependent Variable: Q9.Percieved Sustainability of VF Greens

b. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6,440	1	6,440	19,583	<,001[b]
	Residual	42,422	129	,329		
	Total	48,862	130			

a. Dependent Variable: Q9.Percieved Sustainability of VF Greens

b. Predictors: (Constant), Q5.Attitude towards Food Sustainability

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2,883	,231		12,474	<,001	2,425	3,340
	Q5.Attitude towards Food Sustainability	,292	,066	,363	4,425	<,001	,161	,422

a. Dependent Variable: Q9.Percieved Sustainability of VF Greens

Casewise Diagnostics[a]

Case Number	Std. Residual	Q9.Percieved Sustainability of VF Greens	Predicted Value	Residual
76	-3,843	1,60	3,9329	-2,33290

a. Dependent Variable: Q9.Percieved Sustainability of VF Greens

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3,3203	4,3417	3,8809	,22257	131
Residual	-1,61758	1,29061	,00000	,57125	131
Std. Predicted Value	-2,519	2,070	,000	1,000	131
Std. Residual	-2,821	2,251	,000	,996	131

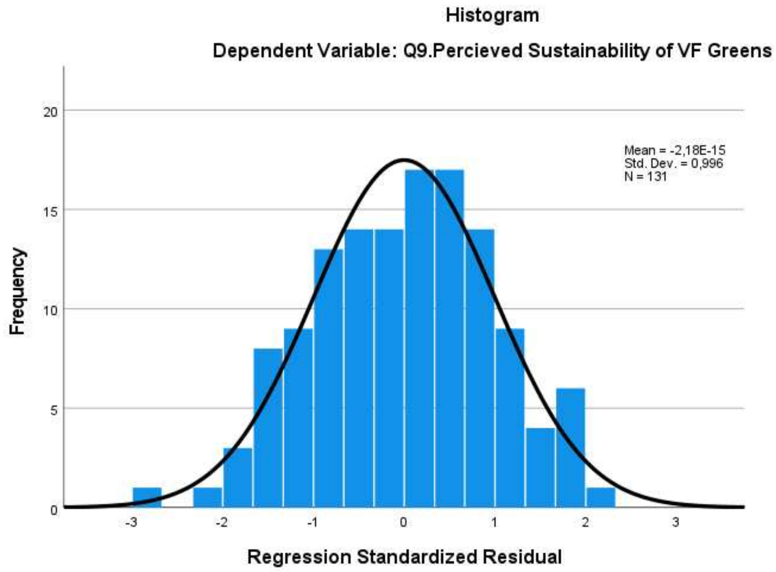
a. Dependent Variable: Q9.Percieved Sustainability of VF Greens

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,363[a]	,132	,125	,57346	1,739

a. Predictors: (Constant), Q5.Attitude towards Food Sustainability

b. Dependent Variable: Q9.Percieved Sustainability of VF Greens



Appendix 14 –Multiple Regressions Analysis

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Would you be willing to pay a price premium for vertically farmed greens?, Q9.Percieved Sustainability of VF Greens, Q7.Subjective Knowledge of VF, Q8.Attitudes towards VF Greens[b]	.	Enter

a. Dependent Variable: Q10.Attitude towards Buying VF Greens

b. All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	43,461	4	10,865	43,540	<,001[b]
	Residual	31,693	127	,250		
	Total	75,154	131			

a. Dependent Variable: Q10.Attitude towards Buying VF Greens

b. Predictors: (Constant), Would you be willing to pay a price premium for vertically farmed greens?, Q9.Percieved Sustainability of VF Greens, Q7.Subjective Knowledge of VF, Q8.Attitudes towards VF Greens

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95,0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	,792	,482		1,646	,102	-,160	1,745		
	Q7.Subjective Knowledge of VF	,114	,060	,138	1,911	,058	-,004	,232	,637	1,570
	Q8.Attitudes towards VF Greens	,477	,138	,318	3,453	<,001	,204	,750	,391	2,556
	Q9.Percieved Sustainability of VF Greens	,396	,090	,336	4,383	<,001	,217	,575	,565	1,770
	Q11.Willing to pay a price premium for vertically farmed greens?	-,241	,102	-,159	-2,364	,020	-,443	-,039	,734	1,363

a. Dependent Variable: Q10.Attitude towards Buying VF Greens

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2,3689	5,3125	4,1439	,57599	132
Residual	-1,09200	1,24388	,00000	,49186	132
Std. Predicted Value	-3,082	2,029	,000	1,000	132
Std. Residual	-2,186	2,490	,000	,985	132

a. Dependent Variable: Q10.Attitude towards Buying VF Greens

Model		Collinearity Statistics	
		Tolerance	VIF
	Q7. Subjective Knowledge of VF	,637	1,570
	Q8. Attitudes Towards VF Greens	,391	2,556
	Q9. Perceived Sustainability of VF Greens	,565	1,770
	Q11. Willing to pay a price premium for vertically farmed greens?	,734	1,363

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,760[a]	,578	,565	,49955	2,279

a. Predictors: (Constant), Would you be willing to pay a price premium for vertically farmed greens?, Q9.Percieved Sustainability of VF Greens, Q7. Subjective Knowledge of VF, Q8.Attitudes towards VF Greens

b. Dependent Variable: Q10.Attitude towards Buying VF Greens