Revolutionizing Dairy: Analysing the Drivers of Consumer Willingness to Pay for Precision Fermentation Cheese

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Abstract

The global food industry of dairy consumption is undergoing a transformative shift, driven by consumer demand for sustainability and ethical production. Precision fermentation (PF), a biotechnology that produces bioidentical milk proteins without animal farming, offers a compelling alternative to traditional dairy products. This thesis investigates the potential for PF cheese in the German market, focusing on the factors influencing consumer willingness to pay (WTP). Through a mixed-methods approach, combining qualitative interviews and a quantitative survey, the study explores the roles of sensory appeal, ethical values, environmental benefits, and transparency in shaping consumer perceptions.

Findings reveal that sensory attributes, particularly taste and texture, are critical to consumer acceptance, yet must be complemented by clear communication of PF's sustainability and ethical advantages. Environmental concerns, including reduced greenhouse gas emissions, resonate strongly with German consumers, as do ethical considerations tied to animal welfare. Transparency about production processes emerges as pivotal for trust-building, especially given concerns surrounding genetic modification.

This study not only advances academic understanding of consumer behaviour but also provides actionable insights for industry stakeholders seeking to navigate the evolving food landscape.

Keywords: Precision Fermentation, Willingness to Pay, Consumer Behaviour, German Dairy Market, Sustainable Food Innovation, Product Innovation, Dairy Alternatives

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Resumo

A indústria alimentar global de consumo de produtos lácteos está a sofrer uma mudança transformadora, impulsionada pela procura de sustentabilidade e produção ética por parte dos consumidores. A fermentação de precisão (FP), uma biotecnologia que produz proteínas lácteas bioidênticas sem a criação de animais, oferece uma alternativa convincente aos produtos lácteos tradicionais. Esta tese investiga o potencial do queijo de fermentação de precisão no mercado alemão, centrando-se nos factores que influenciam a disponibilidade do consumidor para pagar. Através de uma abordagem de métodos mistos - combinando entrevistas qualitativas e um inquérito quantitativo - o estudo explora os papéis da atração sensorial, dos valores éticos, dos benefícios ambientais e da transparência na formação das percepções dos consumidores.

Os resultados revelam que os atributos sensoriais, particularmente o sabor e a textura, são fundamentais para a aceitação do consumidor, mas devem ser complementados por uma comunicação clara das vantagens éticas e de sustentabilidade do PF. As preocupações ambientais, incluindo a redução das emissões de gases com efeito de estufa, têm uma forte ressonância junto dos consumidores alemães, tal como as considerações éticas relacionadas com o bem-estar dos animais. A transparência sobre os processos de produção surge como fundamental para a criação de confiança, especialmente devido às preocupações em torno da modificação genética.

Este estudo não só contribui para a compreensão académica do comportamento dos consumidores, como também fornece informações úteis para as partes interessadas da indústria que procuram navegar na paisagem alimentar em evolução.

Palavras-chave: Fermentação de precisão, disponibilidade de pagar, comportamento do consumidor, mercado alemão de lacticínios, inovação alimentar sustentável, inovação de produtos, alternativas aos lacticínios

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Table of Content

1. INTRODUCTION **1**

1.1 Structure of Thesis **2**

2. LITERATURE REVIEW **2**

2.1 Industry Analysis **2**
2.1.1 Market Overview 2
2.1.2 Challenges and Trends of the Global Dairy Market 4
2.1.3 Challenges and Trends of the German Dairy Market 5
2.1.4 Challenges and Trends of the Global Dairy Alternatives Market 6
2.1.5 Challenges and Trends of the German Dairy Alternatives Market 6

2.2 Definition Precision Fermentation and its Role in the Food Industry **7**

2.3 Consumer Perception **7**
2.3.1 Motivations Driving Consumer Interest 7
2.3.2 Barriers to Consumer Acceptance 8
2.3.3 Building Consumer Trust 8

3. PROBLEM STATEMENT **9**

4. METHODOLOGY **10**

4.1 Qualitative Research **10**

4.2 Quantitative Research **11**
4.2.1 Survey Design 11
4.2.2 Data Collection Method 12
4.2.3 Sample 12
4.2.4 Method of Analysis 13

5. RESULTS **14**

5.1 Qualitative Research **14**

5.2 Quantitative Research **16**
5.2.1 Hypotheses 01 & Hypotheses 02 Testing 16
5.2.2 Hypotheses 03 Testing 17
5.2.3 Hypotheses 04 Testing 18
5.2.4 Hypotheses 05 Testing 19
5.2.5 Hypotheses 06 Testing 19
5.2.6 Research Question Testing 20

6. DISCUSSION **24**

6.1 Analysis and Interpretation **24**

6.2 Managerial Implications **26**

6.3 Further Research **27**

6.4 Limitations **27**

7. CONCLUSION **28**

REFERENCES ..... **I**

APPENDIX A: INTERVIEW GUIDE – QUALITATIVE RESEARCH ..... **V**

APPENDIX B: SUMMARY OF INTERVIEWS ..... **VI**

APPENDIX C: SAMPLE ..... **VII**

APPENDIX D: QUANTITATIVE RESEARCH ..... **IX**

APPENDIX E: HYPOTHESES 01 & 02 TESTING ..... **XII**

APPENDIX F: HYPOTHESES 03 TESTING ..... **XIII**

APPENDIX G: HYPOTHESES 04 TESTING ..... **XIII**

APPENDIX H: HYPOTHESES 05 TESTING ..... **XIV**

APPENDIX I: HYPOTHESES 06 TESTING ..... **XVI**

APPENDIX J: RESEARCH QUESTION TESTING - FACTOR ANALYSIS ..... **XVI**

APPENDIX K: RESEARCH QUESTION TESTING - LINEAR REGRESSION ..... **XIX**

APPENDIX L: RESEARCH QUESTION TESTING - CLUSTER ANALYSIS ..... **XXII**

APPENDIX M: SURVEY ..... **XXIV**

Table of Figures

Figure 1: Frequencies of Survey Question 8……17
Figure 2: Frequencies of Survey Question 13……17
Figure 3: Frequencies of Survey Question 6……..……....20

List of Abbreviations

DMK	Deutsches Milchkontor GmbH
GMO	Genetically Modified Organism
H	Null Hypotheses
KMO	Kaiser-Meyer-Olkin
PF	Precision Fermentation
WTP	Willingness to Pay

1. Introduction

> *"Through fermentation, we create indulgent foods for a more sustainable world"* (Formo, 2024)

This sentiment, expressed by Formo*, captures the essence of a deep shift in the global food industry, where innovation meets sustainability. Precision fermentation (PF) has introduced a new possibility in food production, aiming to reconcile our dietary habits with pressing environmental and ethical challenges. As the world struggles with the crises of climate change and resource scarcity, traditional dairy farming is increasingly criticized for its significant environmental impact, including greenhouse gas emissions and extensive resource consumption. In parallel, consumer consciousness around animal welfare and sustainable practices is reshaping market demands.

This thesis is anchored in the transformative potential of PF, a biotechnology-driven process that uses engineered microorganisms to produce bioidentical proteins, such as casein and whey, without the need for animal farming. Positioned at the crossroad of sustainability, innovation and ethical food production, PF offers an interesting alternative to conventional dairy. However, despite its promise, the pathway to consumer acceptance remains with challenges. In Germany, a market characterized by strong environmental awareness and a rich dairy tradition, the reception of such innovations is dependent on effective communication strategies that address consumer concerns and build trust.

The study explores a critical question: What factors influence German consumers' willingness to pay (WTP) for PF cheese? The study is guided by hypotheses that examine the roles of sensory appeal, ethical considerations, health benefits and transparency in production processes. Central to this investigation is the recognition that consumer trust is not a static construct but one that is dynamically shaped by perceptions, education, and market narratives. By deciphering these dimensions, this thesis aims to contribute to actionable insights in an emerging area of food innovation. In doing so, this research not only expands academic knowledge of consumer behaviour but also informs industry stakeholders on how to effectively market PF products.

The Literature review provides an overview of the global dairy industry's challenges, including its environmental footprint and contextualizes the rise of dairy alternatives in Germany. It highlights the market's evolution towards sustainable and ethical consumption while acknowledging the barriers posed by traditional consumer preferences and regulatory frameworks.

Through a mixed-methods approach combining qualitative interviews and quantitative surveys, this study delves into consumer attitudes, segmenting the market into distinct profiles that reflect varying degrees of openness to innovation and ethical food choices. By analysing these findings,

*Formo is an innovative Berlin-based startup that is revolutionizing the dairy industry, specifically the cheese Industry with their unique approach to animal-free cheese production (Formo, 2024)

the research not only highlights the potential of PF cheese but also highlights the wide implications for aligning food technologies with consumer values in an era of climate urgency.
In essence, this study is not merely about cheese4it is about starting a dialogue between technology, sustainability and consumer expectations. It is the start to explore how trust can be cultivated in a market that is increasingly defined by its demand for transparency, authenticity, and impact.

1.1 Structure of Thesis

This Thesis consists of seven chapters. Following this introduction the second chapter provides a comprehensive literature review, beginning with an overview of the dairy market and its global and local German-specific challenges and trends. It then examines dairy alternatives market, defines PF and explains its role in the food industry, concluding with the insights into current consumer perceptions of PF cheese. Chapter three presents the problem statement, including the definition of the research question and hypotheses, tested in this study. Chapter four details the methodology, while chapter five outlines the findings from the qualitative and the quantitative research. Chapter six analyses these results and relates them to the existing literature, derives managerial implications, discusses limitations and offers an outlook to future research in this emerging field.

2. Literature Review

2.1 Industry Analysis

2.1.1 Market Overview

In the world of milk, cheese, yogurt and more a transformation is unfolding where tradition meets innovation, driven by growing awareness of the environmental and ethical changes of conventional dairy production. As consumers' tastes evolve and environmental concerns grow, the dairy industry finds itself facing challenges and opportunities that are reshaping the landscape of our daily bread and butter.
The global dairy market is experiencing significant growth and transformation, even though more people are worried about how it affects the environment. Valued at 944.7 billion USD in 2023, it is projected to reach 1.5 trillion USD by 2032, with a 4.95% growth rate and key players such as Nestlé, Danone, Arla Foods or Lactalis dominating the international market (Henderson, 2024). This global market is led by major exporters including the European Union, New Zealand, the United States and Chinese companies which are expanding their presence in the emerging market (Bojovic and McGregor, 2022).

In Germany, the dairy market is also thriving. Valued at 30.35 billion USD in 2024, it is expected to grow to 38.64 billion USD by 2029 where leading players currently include the Müller Group, Arla Foods, Danone and Group Lactalis (Mordor Intelligence, n.d.). The German dairy market is highly concentrated, with the top 10 companies accounting for 65% of the market turnover (Höhler and Kühl, 2019). It is characterized by large producer cooperatives and private processors controlling most of the supply chain. The market has seen a significant reduction in small farms, with production concentrated in fewer, larger operations (Barling et al., 2021). Deutsches Milchkontor GmbH (DMK) is the largest dairy in Germany, processing around 6.3 billion kilograms of milk annually from over 5,200 producers (Knuck, 2023). European dairies from Denmark, Sweden and France also have a strong presence.

Alongside traditional dairy market, the alternatives market is experiencing rapid growth globally. Major players in this sector include Danone (with brands like Alpro and Silk), Oatly and Nestlé (Adamczyk et al., 2022).

Germany is among the top three European countries for dairy substitute consumption, with milk alternatives reaching value of 680 million USD in 2023 (STATISTA, 2023). It indicates a growing awareness of the ethical and environmental benefits of plant-based alternatives. Key players in this growing plant-based and dairy alternatives sector are Oatly, Alpro (Danone) and even traditional companies like DMK Group. (Höhler and Kühl, 2019).

DMK Group while still active in the traditional milk market, has diversified its portfolio into plant-based products to keep pace with consumer demand (Höhler and Kühl, 2019). As a major player and subsidiary of Danone, Alpro maintains a strong presence in the German market, offering products such as almond, soy and oat milk as well as yogurt (Adamczyk et al., 2022). Notably Danone, as one of the global leaders in plant-based alternatives, is expanding its range of non-dairy milk, yogurt and cheese alternatives (Adamczyk et al., 2022). The Swedish company Oatly has also secured a strong position in Germany with its oat-based milk alternatives (Adamczyk et al., 2022). Their focus on sustainable, eco-friendly branding resonates with German consumers, making them a market leader in the oat-milk segment (Adamczyk et al., 2022). It is worth noting that the global food giant Nestlé has entered the dairy alternatives market with its plant-based product lines, aiming to compete in the rapidly expanding segment (Adamczyk et al., 2022). Their focus primarily lies in milk and yogurt alternatives. While these brands clearly emphasize milk and yogurt products, it is important to remember that cheese is a vital and popular product in the dairy world, as cheese remains a cornerstone of the German dairy industry, accounting for 38.53% of the market value (Mordor Intelligence, n.d.). Even here, plant-based alternatives are gaining traction, with 16% of consumers

reporting recent consumption (STATISTA, 2023). This shift towards plant-based alternatives poses both challenges as well as opportunities for traditional dairy firms.

However, the growth of these alternatives is not without controversy. Some argue that while disrupting the traditional dairy sector, they may reinforce corporate control over food systems without fully addressing environmental or social equity issues (Bojovic and McGregor, 2022).

The future of the industry will likely be shaped by those companies that can successfully balance tradition with innovation, meeting the demands for both conventional dairy products and sustainable alternatives.

2.1.2 Challenges and Trends of the Global Dairy Market

The global dairy industry faces numerous challenges, many of which revolve around environmental sustainability and market pressures. One significant challenge is the increasing demand for dairy products because of the rising population, predicted to reach 9.7 billion by 2050 (Tello et al., 2021). This growth leads to an elevated demand for resources, including land and water which are essential for dairy production. Additionally, the environmental impact of dairy production is very significant, including high greenhouse emissions, particularly methane from cattle (Mihai et al., 2023; Beber et al., 2021). The Food and Agriculture Organization of the United States estimates that livestock accounts for 14.5% of global livestock emissions, with dairy cattle contributing around 1.6 gigatons of CO2 equivalents annually (Tello et al., 2021; Mihai et al., 2023; Carlsson Kanyama et al., 2021). This environmental burden is intensified by concerns over animal welfare and the need for more sustainable dairy farming practices, especially in response to the growing consumer preference for ethical and sustainable products (Mihai et al., 2023). Alongside environmental concerns, the industry also struggles with price volatility and increasing production costs, influenced by global market fluctuations and charging consumer demand (Knuck, 2023).

Simultaneously, there is a growing trend towards the development of plant-based alternatives to dairy products, driven by sustainability and health concerns. Plant-based alternatives to dairy products, such as oat and almond milk, are perceived to have a lower environmental footprint compared to traditional dairy, particularly in terms of greenhouse gas emissions and land use (Beber et al., 2021; Carlsson Kanyama et al., 2021). However, some products, like for example almond milk still raise concerns over water consumption, particularly in water-scarce regions (Leialohilani et al., 2020; Carlsson Kanyama et al., 2021). Regulatory frameworks, especially in the European Union, play a significant role in both enabling and constraining innovation in this sector. For instance, EU regulations around the labelling of dairy alternatives create challenges for producers of plant-based products because terms like “milk”, “yogurt” and “cheese” are legally restricted to animal-derived

products (Leialohilani et al., 2020; Carlsson Kanyama et al., 2021). Despite these challenges, the plant-based dairy market is expanding rapidly, driven by consumer demand for healthier, more sustainable options. Studies show that plant-based dairy alternatives can reduce greenhouse gas emissions as well as resource use, highlighting their potential to contribute significantly to climate change mitigation efforts (Carlsson Kanyama et al., 2021; Banach et al., 2023). This shift represents a major trend in the global dairy industry, which must adapt to these pressures to ensure future sustainability and market competitiveness.

2.1.3 Challenges and Trends of the German Dairy Market

The German dairy industry faces challenges, many of which mirror global trends but also reveal distinct regional characteristics. One of the key challenges is balancing the increasing consumer demand for sustainable and ethically produced dairy products with the realities of a competitive market. Like many international markets, the German dairy industry is also struggling with growing consumer awareness of environmental impact, animal welfare and transparency. These concerns are reflected in consumer preferences for products such as organic and pasture-raised milk, as well as the shift towards plant-based alternatives, which has been increasingly observed in global markets (Tello et al., 2021; Meyerding and Seidemann, 2024; Beber, 2021). However, Germany stands out in its unique response to these demands with its consumers demonstrating a particularly strong focus on animal welfare and sustainable packaging solutions, such as a preference for glass over plastic (Meyerding and Seidemann, 2024; Höhler and Kühl, 2019). German consumers also stand out when it comes to increasingly prioritizing animal welfare with a growing preference for pasture-based milk and organic dairy products, which contrasts with global trends where price remains the dominant factor in consumer decision-making (Meyerding and Seidemann, 2024). This shift is driven by a combination of ethical considerations and environmental awareness, with more consumers willing to pay a premium for products that ensure better husbandry practices (Höhler and Kühl, 2019; Banach et al., 2023). Moreover, Germany's dairy industry is marked by a competitive structure where smaller farmstead dairies have an opportunity to thrive through niche marketing strategies, offering regionally produced, high-quality products (Knuck, 2023). These farmstead dairies help to diversify the market, providing an alternative to large-scale dairy production, which often struggles with price volatility and global market saturation (Knuck, 2023; Mihai et al., 2023). While both the global and the German market face sustainability issues, Germany's regulatory framework and consumer preferences create distinct market dynamics, positioning it as a leader in sustainability and animal welfare within the dairy industry.

2.1.4 Challenges and Trends of the Global Dairy Alternatives Market

The global dairy alternatives market is undergoing rapid growth, driven by increasing consumer awareness about health, sustainability and environmental concerns. The demand for plant-based and alternative proteins has surged as more people seek to reduce their intake of animal-derived products. Innovations in plant-based milk, yogurt, cheese and other dairy substitutes, as well as alternative proteins from sources such as algae and insects are transforming the food industry, allowing consumers to make more sustainable choices. (Tello et al., 2021; Banach et al., 2023; Mihai et al., 2023). Nevertheless, the development of these products presents challenges, such as creating functional and nutritional profiles that match traditional dairy products (Tello et al., 2021; Banach et al., 2023).

Despite the growth of the alternatives market, significant challenges remain, particularly in scaling production and ensuring product safety. Regulatory frameworks in regions like the EU can both support and hinder innovation, as legislation related to labeling and food safety must adapt to emerging dairy alternatives (Leialohilani et al., 2020). In addition, the processing of plant-based proteins may lead to issues like allergenicity and anti-nutritional compounds, posing a risk to food safety (Banach et al., 2023). Furthermore, overcoming consumer misconceptions, especially regarding the environmental impact of certain alternatives like almond-based products, also remains a challenge for the industry (Carlsson Kanyama et al., 2021). As this market continues to expand, the dairy alternatives sector is poised to play a critical role in the global food industry, with continued innovation expected to drive further growth.

2.1.5 Challenges and Trends of the German Dairy Alternatives Market

The German dairy alternatives market mirrors global trends, but it also has distinct characteristics that set it apart. In Germany, consumer preferences are increasingly influenced by concerns about sustainability, health and animal welfare with a special focus on organic and free-range dairy alternatives (Meyerding and Seidemann, 2024, Höhler and Kühl, 2019). The market for plant-based dairy alternatives in Germany has expanded significantly as consumers look for products that align with their values. However, the regulatory landscape in the EU present unique challenges for German producers in this sector (Leialohilani et al., 2020). Despite these circumstances, there is substantial consumer demand for innovative products that mimic the taste and functionality of traditional dairy, driving companies to invest in new formulations and sustainable practices (Mihai et al., 2023; Höhler and Kühl, 2019).

A key distinction in the German market is the strong emphasis on animal welfare and environmental sustainability, reflected in the high demand for products labelled as organic or produced with high animal welfare standards (Höhler and Kühl, 2019). While both the global and German markets share similar drivers, Germany's focus on local production stands out. German consumers are also more sensitive when it comes to packaging and price transparency, which plays a significant role in shaping purchasing decisions (Meyerding and Seidemann, 2024). Additionally, while plant-based alternatives dominate both markets, Germany's niche for high-quality, ethical dairy alternatives gives it a distinctive edge in the European landscape. (Höhler and Kühl, 2019; Knuck, 2023).

2.2 Definition Precision Fermentation and its Role in the Food Industry

Precision fermentation is a biotechnology-driven process that relies on engineered microorganisms, such as yeast, fungi, or bacteria to produce specific compounds like enzymes, proteins, lipids and pigments (Chai et al., 2022; Teng et al., 2021). Unlike traditional fermentation, which uses unmodified microbes to produce fermented foods, PF involves modifying the DNA of organisms under controlled conditions to produce bioidentical milk proteins without the need for animals (Chai et al., 2022; Teng et al., 2021; Thomas and Bryant, 2021).

In the food industry, PF is recognized for its efficiency, sustainability and ability to replace animal-derived ingredients, creating a shift in the food production. For example, engineered microbes can produce milk proteins like casein and whey without animal farming, providing alternatives for dairy products that replicate the texture, taste and nutritional qualities of animal-based foods (Boukid et al., 2023). The process not only supports environmental objectives by reducing resource use and greenhouse gas emissions but also aligns with the growing demand for alternative proteins that address ethical and environmental concerns (Broad et al., 2022; Teng et al., 2021). This technology enables the scalable production of a wide range of high purity ingredients, impacting various segments of the food industry, from plant-based dairy and meat to sustainable sources of food additives, vitamins and natural flavourings (Kühl et al., 2024; Chai et al., 2022). PF allows companies to produce ingredients that would otherwise require extensive agricultural or animal resources, promoting both food security and food safety on a global scale (Teng et al., 2021).

2.3 Consumer Perception

2.3.1 Motivations Driving Consumer Interest

PF has gained attention as a sustainable solution for food production, primarily due to its ethical and environmental benefits. Consumers are increasingly seeking food products that reduce

animal cruelty and environmental destruction (Broad et al., 2022; Kühl et al., 2024). PF addresses these concerns by enabling the production of animal-free proteins and other ingredients that can replicate the sensory experience of traditional animal products. For example, proteins like casein and whey, which are crucial for the texture of dairy products, can now be produced without animals, appealing to consumers who value sustainability and ethical consumption (Kühl et al., 2024; Broad et al., 2022). In addition, health-conscious consumers are attracted by the controlled production environment of PF, which can minimize the need for preservatives and additives often found in plant-based alternatives (Boukid et al., 2023). Studies show that PF can produce products with higher protein content and lower fat levels compared to traditional animal-based foods, making it as an attractive option for health-oriented consumers (Chai et al., 2022).

2.3.2 Barriers to Consumer Acceptance

Despite all these advantages, PF faces several barriers on the way to widespread consumer acceptance. One major obstacle is the association with genetically modified organisms (GMOs). Since PF often involves modifying microbial genomes, some consumers view the process as unnatural or synthetic, similar to concerns seen with genetically modified foods (Kühl et al., 2024). This perception is particularly strong in Europe, where GMO regulations are strict and consumer attitudes more cautious (Kühl et al., 2024). Safety and transparency are other key concerns. Consumers are hesitant regarding the regulatory frameworks of these novel foods, especially since PF is relatively new in the consumer food market (Broad et al., 2022). Additionally, some consumers are wary of the involvement of large biotechnology firms in this area, fearing that PF could centralize control over the food supply, impacting smaller farms and traditional food producers (Kühl et al., 2024; Teng et al., 2021). This mistrust of corporate dominance can create a barrier to trust, especially among consumers who prefer traditional, locally-sourced foods.

2.3.3 Building Consumer Trust

To address these barriers, companies need to prioritise transparency in their production processes and educate consumers on the benefits of PF (Boukid et al., 2023). Marketing strategies should emphasize the focus of these products on natural food processing techniques, highlighting the sustainable and ethical dimensions of PF (Boukid et al., 2023). Providing consumers with detailed information about the safety measures and regulatory standards involved in PF can help alleviate concerns about the technology's impact on health and food safety (Broad et al., 2022). Educational awareness campaigns that explain the environmental benefits, such as reduced resource use and lower

greenhouse gas emissions, may shift consumer attitudes toward greater acceptance, especially among those unfamiliar with the technology (Teng et al., 2021). By positioning PF as a controlled and sustainable process, companies can build consumer trust and demonstrate that these foods offer a meaningful alternative to conventional animal products.

3. Problem Statement

As the German dairy industry undergoes significant transformation with the rise of alternative products, effectively communicating complex, science-based innovations like PF cheese presents a unique challenge. Consumer trust might be a pivotal factor in the acceptance of these novel products, and a key obstacle lies in how the fermentation process and associated benefits are communicated to the public. Given that German consumers are highly concerned with sustainability, animal welfare, and environmental impact, the perception of PF cheese could be influenced by how transparent and understandable the communication surrounding its production process is.

Despite the potential benefits of PF cheese, there is a lack of clarity about what drives or hinders consumer WTP for such products. Are consumers sceptical due to unfamiliarity with the technology, or are they willing to pay premium prices for innovations that align with their ethical values? Identifying the communication strategies that bridge the gap between scientific innovation and consumer expectations is crucial for the successful adoption of PF cheese. This thesis seeks to investigate the communication-related drivers influencing German consumers' WTP for PF cheese, aiming to offer insights into building trust and promoting acceptance in a rapidly evolving food market. Guided by this Problem statement the goal is to answer the following research question:

RQ1: What are the key drivers affecting German consumers' willingness to pay for precision fermentation cheese?

Hypotheses 01: *The taste contributes positively to the willingness to pay for precision fermentation cheese.*

Hypotheses 02*: The texture contributes positively to the willingness to pay for precision fermentation cheese.*

Hypotheses 03: *The communication of environmental benefits (e.g., lower greenhouse gas emissions) affect the willingness to pay positively.*

Hypotheses 04: *The communication of health benefits, like improved nutritional value, affects the willingness to pay positively.*

Hypotheses 05: *The communication of the production process affects the willingness to pay positively.*

Hypotheses 06: *Ethical considerations, including animal welfare concerns, contribute positively to the willingness to pay for precision fermentation cheese.*

By addressing these questions, the study aims to provide a comprehensive understanding of the communication challenges and opportunities surrounding fermentation-produced cheese in the German market. These findings will contribute to developing targeted communication approaches that can enhance consumer acceptance and support the successful introduction of this innovative product in Germany's evolving food landscape.

4. Methodology

4.1 Qualitative Research

This study uses a qualitative exploratory research design to explore consumer perceptions, motivations and barriers to adopt PF cheese. Semi-structured interviews are conducted to collect primary data, as they are a standard research method for qualitative research (Bansal et al., 2018). Semi-structured interviews use a pre-defined interview guide to provide structure for the interviewer and respondents (refer Appendix A).

A diverse group of ten individuals is interviewed over one and a half weeks to capture a broad representation of the German market within the project's short timeframe. This group includes participants ranging from 21 to 46 years of age, from which seven individuals are female and three are male. The interviewees are based in Germany. The sample is further divided into seven students, three professionals to represent different socioeconomic factors. Additionally, the dietary habits of the participants are diverse, as two participants are strict vegetarians, one pescetarian and seven omnivores. This heterogeneous group allows the collection of a wide range of perspectives, attitudes and experiences from other sociodemographic groups in Germany.

The interviews are conducted either in German or English, depending on the participant's preference, to ensure the ease of expression. Open-ended questions are used to generate detailed and comprehensive responses, aiming to thoroughly understand participant's opinions. Due to geographical constraints and to make it easier for participants interviews are conducted using two main methods of telephone interviews as well as face-to-face meetings. The interviews are audio-recorded for transcription and analysis to ensure the accuracy of the data, enable precise analysis and increase the validity of the research. This ensures transparency, allows reference feedback during further analysis and allows for the original statements to be accessible to other researchers.

The interview is divided into four blocks where the first covers the topic of general awareness and initial perceptions of PF. The second block includes motivations and barriers to try cheese

alternatives, followed by the third block regarding factors influencing WTP for innovative food products. At the end the fourth block finishes with questions regarding broader attitudes toward food technologies and genetic modification.

The transcribed interviews are analysed using the content analysis approach by Philipp Mayring, which provides a systematic approach to interpret and evaluate texts (Baur and Blasius, 2014). This process involves the steps of familiarization, coding, categorization, interpretation and validation (Schnell et al., 2013). First the data is familiarized by reading and re-reading the interview transcripts to gain a comprehensive understanding (Schnell et al., 2013). The next stage, coding, involves identifying recurring words, phrases and themes related to participant's perceptions, motivations and barriers. These codes are then categorized into broader thematic groups, such as "taste and texture", "ethical considerations", "health considerations" and "trust in technology". Then the data is interpreted by examining patterns within and across participants to identify similarities and differences in their responses. Finally, to ensure the reliability of the analysis, a validation step is used, cross-checking coded data and themes to ensure consistency and accuracy throughout the analytical process. Furthermore, the analysis is conducted iteratively, allowing themes to emerge organically while maintaining alignment with the study's research questions.

4.2 Quantitative Research

4.2.1 Survey Design

To build on the qualitative research findings, a detailed quantitative analysis is conducted through an online questionnaire. The primary objective of the study is to gain insights into the feasibility of introducing alternative dairy products, specifically PF cheese, in the German market. By utilizing an online survey, the research aims to understand consumer preferences, attitudes, and potential demand for this innovative food technology. The advantages of conducting an online survey include rapid data collection within a short time frame, structured and cost-effective data gathering, and simplified analysis using digital tools (Wright, 2006). Furthermore, respondents can complete the survey at their convenience, and real-time data analysis is possible.

The survey is structured into several sections. It begins with an introductory block, followed by screening questions to ensure participants meet the criteria for the study (e.g., living in Germany). Next, the survey explores consumer behaviour by assessing participants dietary preferences and restrictions. A subsequent block introduces the concept of PF and includes questions to figure out participants interest in the technology.

The survey includes questions assessing participants perceptions, such as motivating factors for trying PF cheese, their concerns, and their likelihood to try, trust, and recommend the product. The final section consists of psychographic and demographic questions. This structured approach ensures a comprehensive analysis of consumer attitudes and behaviours toward PF cheese. It allows to quantify the data and draw conclusions from the sample that can be generalized to the target population (Wright, 2006).

4.2.2 Data Collection Method

The marketing research survey was conducted from November 22nd until December 6th 2024, using the Qualtrics platform. To gather a sufficient number of participants, the survey was conducted in English and distributed through various social media platforms, including Instagram, Facebook, LinkedIn and WhatsApp. In addition, the survey was posted on the "Surveycircle" community website and its associated network. Due to this data collection method, individuals without internet access or outside the social networks and communities of this study's researcher were excluded. The study included a mix of question types: Likert scale questions to measure attitudes and preferences; Multiple choice questions to gain a deeper understanding of consumer habits and perceptions related to dietary patterns and specific aspects of PF; Open-ended questions which encouraged detailed responses to avoid overly standardized answers. The survey also included a screening question to filter participants based on the key requirement of the German residency. Q28 tested the participant's attention, which was crucial for ensuring data quality and excluding inattentive respondents (refer Appendix M).

Demographic questions were included to better understand the characteristics of the target audience.

4.2.3 Sample

Out of 129 total respondents, 117 completed the survey fully. The target population of this study consists of participants living in Germany; therefore, ten participants were excluded from further analysis because they did not meet the criteria. This was ensured through a filter question in the beginning of the questionnaire. Additionally, six participants failed the attention check question and three responses had technical transmission errors. This resulted in 98 valid responses that were used for further analysis.

A convenience sampling, a non-probability sampling technique, is used. It selects participants based on their availability and willingness to participate. This method includes people who are easily accessible and is chosen due to its practicality and the need to collect a large amount of

data in a short period of time (Jager et al., 2017). Nevertheless, it is important to note that this approach may lead to biased responses and the sample might not be representative of the entire population (Jager et al., 2017). Given the resource constraints (budget and time) an ad hoc sample is drawn. Ad hoc sampling involves a method of collecting data in which samples are drawn without extensive pre-planning (Cardoso et al., 2009). This approach offers a combination of flexibility as well as cost-effectiveness and allowing researchers the quick possibility of addressing specific questions or issues as they arise (Cardoso et al., 2009).

The demographic profile which is collected includes the attributes of Age, Gender, Dietary preferences as well as the annual gross household income and occupational situation. About 28.6% of the respondents are under 25 years old and 56.1% are between 25-35 years old, meaning that the majority of respondents (84.7%) are 35 years or younger (refer Appendix C, Table1). The 15.3% of individuals over the age of 35 consist of 6.1% aged 36-45, 5.1% aged 46-55 and 4.1% aged over 55 (refer Appendix C, Table 1).

In Terms of Gender distribution, 58.2% of the participants identify as female, while 41.8% identify as male, showing slight dominance of the female gender (refer Appendix C, Table2).

Concerning the household income, about a quarter of respondents (25.5%) report earnings below ¬20,000 annually, while 20.4% earn ¬20,001-¬40,000 and another 20.4% earn ¬40,001-¬60,000 (refer Appendix C, Table 4). A smaller group (9.2%) reports incomes between ¬60,001-¬80,000 and 18.4% indicate that they earn more than ¬80,000. Additionally, 6.1% choose not to disclose their income (refer Appendix C, Table 4). Regarding the occupational status slightly over half of the respondents (51.0%) report being employed, while 34.7% are students (refer Appendix C, Table 5). A smaller portion (9.2%) are self-employed, 1.0% are in apprenticeships and 4.1% select “other”, highlighting a majority of working professionals and students (refer Appendix C, Table 5).

Participants are also asked about their dietary preferences. More than half of the respondents (53.1%) describe themselves as omnivores, while 20.4% identify as flexitarians (refer Appendix C, Table 3). Vegetarians make up 13.3% of the sample, pescatarians 6.1% and vegans 5.1%. Only 2% choose “other” to describe their dietary habits, highlighting diversity in dietary preferences among the participants (refer Appendix C, Table 3).

4.2.4 Method of Analysis

The statistical package SPSS 29 from IBM is used to analyse the collected data.

This study utilizes a statistical approach with a 5% significance level. The methodology includes a mix of statistical methods, including Frequencies, Descriptives, Linear Regression, Factor Analysis and Cluster Analysis.

The Descriptives provide valuable insights into key survey responses, particularly regarding attribute importance and consumer concerns. The ordinal data (including Likert scales) is treated as metric to enable more robust analysis, while carefully maintaining data integrity across binary, ordinal, and metric scales.

The core analysis focuses mostly on linear regression, which examines how various factors influence consumers' WTP. The independent variables are derived from both individual survey questions and factors identified through factor analysis. The factor analysis is concluded, as first results indicate that the chosen factors through the qualitative research are insufficient to fully address the research question. In addition, the factor analysis simplifies the initial set of variables into three broader dimensions. To fully explore segments within the sample population an additional cluster analysis is conducted where distinct consumer groups are identified, presenting deeper insights into market segmentation.

5. Results

5.1 Qualitative Research

Based on the conducted interviews on consumer perception and WTP of PF cheese, a comprehensive picture of consumer attitudes and perceptions has emerged. The qualitative study reveals both opportunities and challenges for the adoption of this innovative food technology in the market.

General awareness of PF among interviewees is limited, with nine out of ten participants unfamiliar with the concept prior to the interview. Initial responses vary from enthusiasm to scepticism. Eight respondents, like Interviewee No. 09 show high levels of interest, describing PF as a potentially disruptive innovation in food systems. In contrast, others, like Interviewee No. 05, express scepticism about the necessity of such technology given the availability of traditional options or scepticism regarding altering DNA for food production and potential health and ethical implications.

Therefore, common reactions to the concept of PF cheese fall into two main categories: curiosity and scepticism. Interviewee No. 10, expresses intrigue and a desire to try the product, viewing it as an opportunity to engage with an innovative and sustainable food solution.

The analysis identifies several key motivators driving respondents’ interest in cheese alternatives. Animal welfare is a significant factor to both Interviewee No. 04 and No.10, explicitly linking their consumption of plant-based or alternative products to concerns about the treatment of dairy cows. Sustainability is another strong driver, with seven out of ten respondents acknowledging the environmental issues of traditional dairy farming. Health concerns also play a role, with Interviewee No. 06 expressing a preference for products with clean labels and minimal processing.

Additionally, curiosity and the desire to experiment with new food products motivate Interviewee No. 05 and No. 06 to explore cheese alternatives.

Despite the perceived benefits of PF cheese, several barriers to consumer acceptance are identified. Taste and texture issues are the most frequently cited challenges, with Interviewee No. 02 describing existing cheese alternatives as “plastic-like” or “crumbly and artificial”. The inability of vegan cheese to melt properly is highlighted by Interviewee No. 05 and No. 02 as a significant limitation for certain culinary applications. Another major barrier is the association with generic modification, which respondents No. 05, No.06 and No. 08 find concerning. The concept of generic engineering in food production is perceived as unnatural, influencing product perceptions negatively. Also, uncertainty about the long-term health impacts of consuming genetically modified foods is a concern among these participants.

WTP for PF cheese varies among respondents and is influenced by several factors. Taste and authenticity are described as critical, with Interviewees No.05, No. 08 and No. 10 indicating they would pay more for products that closely resembled conventional cheese in flavour and consistency. Environmental and ethical considerations also play a role in WTP, with clear communication about the sustainability benefits of PF potentially influencing purchasing decisions positively, as stated by Interviewees No.02, No.08 and No. 10. Transparency and labelling were identified as crucial elements in building consumer trust, with respondents No.01, No.06 and No. 10 emphasizing the importance of understanding the production process and ingredient composition.

The analysis reveals a divergence in consumer segments based on dietary habits and familiarity with food innovation. Open and experimental consumers, like Interviewee No. 05 and No. 09, demonstrate a willingness to try new products driven by curiosity and openness to innovation. In contrast more traditional consumers, such as Interviewee No. 07, are less inclined to explore alternatives, communicating their satisfaction with conventional products and concerns over unfamiliar textures and flavours.

Although there is scepticism about specific aspects of PF, there is a general openness to explore food technologies among participants. Some respondents, like Interviewee No. 08 and No.10, acknowledge that while genetic modification sounds intimidating, they would be willing to try PF cheese if it were proven safe and the process was transparent. Others, such as Interviewee No.06, see PF as a promising avenue for ethical and sustainable food production but emphasize the need for public education and trust-building efforts.

In conclusion the qualitative results reveal that while PF cheese offers promising ethical and environmental benefits, its successful market adoption depends on addressing consumer concerns

about taste, texture and genetic modification through transparent communication and aligning product development with consumer expectations.

5.2 Quantitative Research

To start the analysis, a linear regression is conducted using the attributes in Q6 as the independent variable and Q12 as the dependent variable. Q6, measured on a 5-point Likert scale (1 = "Not at all important" to 5 = "Extremely important"), captures the importance of various attributes and Q12 is measured on a metric scale (1 = "Less than traditional cheese" to 5 = "More than 25% more than traditional cheese"). The results of the ANOVA show a p-value of 0.076 ($p > 0.05$), indicating that the null hypothesis (H_0) cannot be rejected, that the factors, like e.g., Taste, have no effect on the WTP for PF cheese (refer Appendix D, Table 6). Pearson correlation values among the variables are all below 0.8, confirming the absence of multicollinearity (Appendix D, Table 7).

5.2.1 Hypotheses 01 & Hypotheses 02 Testing

Hypotheses 01: The taste contributes positively to the willingness to pay for precision fermentation cheese.

Hypotheses 02: The texture contributes positively to the willingness to pay for precision fermentation cheese.

To address Hypotheses 01 and Hypotheses 02 descriptive analysis is conducted first. Q7 asks respondents to identify primary concerns regarding PF cheese, using a multiple-choice format. These factors are rated on a non-metric scale, specifically a binary scale (0 = not selected, 1 = selected). The descriptive analysis reveals that taste (M = 0.73) is the most relevant concern for consumers, followed by health (M = 0.49). Other concerns such as safety (M = 0.38), price (M = 0.37), texture (M = 0.36), and lack of information on production processes (M = 0.32) are rated similarly but lower in importance. The lowest score attributed to the association with genetic modification (M = 0.29) (refer Appendix E, Table 8).

The data from Q8 (Likelihood to try PF cheese if it tastes similar to traditional cheese) and Q13 (Likelihood to recommend based on satisfaction with taste and texture) is ordinal in nature, due to the response options ranging from “Extremely Unlikely” to “Extremely Likely”. While these responses are technically non-metric, they are treated metric for statistical purposes. Q8 shows that 88.8% of respondents are somewhat or extremely likely to try PF cheese, with 37.8% indicating they are extremely likely to try it (refer Appendix E, Table 9). Additionally, Q13 indicates that 85.7% of

respondents are somewhat or extremely likely to recommend the product, emphasizing the importance of these sensory attributes for consumer acceptance (refer Appendix E, Table 10).

In Q6, where the individuals are asked how important a certain factor is to try PF cheese, 58.2% rate taste as “Extremely important” and 33.7% rate it “Very important”, suggesting it is a significant motivator, totaling 91.9% of the sample (refer Appendix E, Table 11). In contrast, texture emerges as a slightly less significant motivator, with 34.7% rating it as "Extremely important" and 44.9% as "Very important," totaling 79.6% of the sample (refer to Appendix E, Table 12). Notably, only 2% of respondents rated taste as "Slightly important" or "Not at all important," while for texture, this figure is slightly higher at 3.1% (refer to Appendix E, Table 11; Table 12). These results highlight the strong influence of sensory attributes, particularly taste, in driving interest in PF cheese.

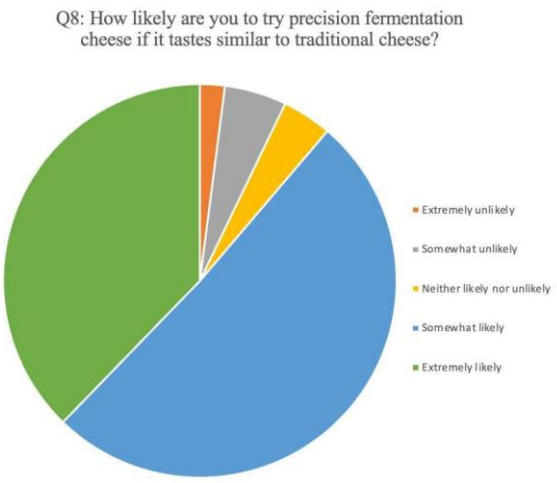

Figure 1: Frequencies of Survey Question 8

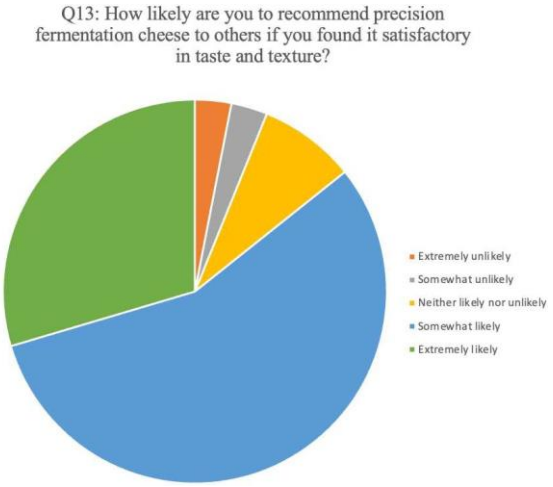

Figure 2: Frequencies of Survey Question 13

5.2.2 Hypotheses 03 Testing

Hypotheses 03: The communication of environmental benefits (e.g., lower greenhouse gas emissions) affects the willingness to pay positively.

Q10 (Type of information that would increase confidence), is a multiple-response question where participants can select multiple options from predefined categories. The responses are recorded on a binary scale (0 = not selected, 1 = selected) and analysed as part for each category, providing metric insights.

The results from Q10 reveal that 40.8% of respondents identify "Details on environmental impact" as an information that would make them feel more confident about purchasing PF cheese (refer

Appendix F, Table 13). This indicates moderate interest in environmental communication among participants in comparison to other factors.

The results indicate that environmental sustainability is a significant motivator for trying PF cheese, with 46.9% of respondents rating it as "Very important" and 22.4% rating it as "Extremely important", accounting for nearly 70% of the total sample (refer Appendix F, Table 14). A smaller proportion, 24.5%, found it "Moderately important", suggesting that most respondents perceive sustainability as a relevant factor (refer Appendix F, Table 14). Only 6.1% of participants considered it "Slightly important" or "Not at all important," indicating minimal resistance to sustainability messaging (Appendix F, Table 14).

5.2.3 Hypotheses 04 Testing

Hypotheses number 04: The communication of health benefits, like improved nutritional value, affects the willingness to pay positively.

To test Hypothesis 04, the descriptive analysis uses Q10 (Type of information that would increase confidence). 74.5% of respondents view "Details on health" as the type of information that would make them feel more confident in purchasing PF cheese (refer Appendix G, Table 15). This is the most frequently selected category, indicating strong consumer interest in the communication of health-related benefits.

The Frequency results of Q6 outline the importance of health benefits as a motivating factor for trying PF cheese. Among respondents, 38.8% rate health benefits as "Very important," and 30.6% rate it as "Extremely important," collectively accounting for 69.4% of the sample (refer Appendix G, Table 16). Meanwhile, 20.4% rate it as "Moderately important," while 6.1% and 3.1% rate it as "Slightly important" and "Not at all important" (refer Appendix G, Table 16). This distribution demonstrates the varied perceptions of health benefits as a motivator, with the majority of respondents assigning high importance to this factor.

The results of Q7 represent the frequency of health-related concerns regarding PF cheese. Here, 49% of respondents identify health as a primary concern, while 51% do not select health as one of their main concerns (refer Appendix G, Table 17). This result indicates the division in how respondents perceive the health-related aspect.

5.2.4 Hypotheses 05 Testing

Hypotheses number 05: The communication of the production process affects the willingness to pay positively.

The analysis of Q10 reveals that 70.4% of respondents select "Explanation of the production process" as a type of information that would make them feel more confident in purchasing PF cheese (refer Appendix H, Table 18). Additionally, Q7 shows that the mean rating for "lack of information about the production process" is 0.32, suggesting moderate relevance of this concern among participants (refer Appendix E, Table 8).

A linear regression analysis of Q10 and Q12 is conducted to test whether communication about the production process significantly affects WTP. The ANOVA for this regression model produces a p-value of 0.083, which is above the significance threshold. As a result, the H fails to be rejected (refer Appendix H, Table 19).

The Frequency results of Q6 show the importance of curiosity about new food technologies in motivating respondents to try PF cheese. Among respondents, 30.6% rate it as "Moderately important," while a smaller group rate it as "Very important" (11.2%) and "Extremely important" (6.1%), collectively making up 47.9% of the sample (refer Appendix H, Table 20). Meanwhile, 27.6% consider it "Slightly important," and 23.5% rate it as "Not at all important," suggesting that curiosity about new technologies hold varying levels of importance across participants (refer Appendix H, Table 20).

5.2.5 Hypotheses 06 Testing

Hypotheses 06: Ethical considerations, including animal welfare concerns, contribute positively to the willingness to pay for precision fermentation cheese.

The answers in Q10 display that 68.4% of respondents select "Certification from trusted organizations" as important for increasing confidence in purchasing PF cheese (refer Appendix I, Table 21). This suggests that ethical assurances play a role in consumer decision-making.

Q7 (Primary Concerns) descriptives show that the ethical concern of animal welfare receive a mean rating of M=0.32, indicating a moderate level of importance as a primary concern for consumers (refer Appendix E, Table 8). This suggests ethical considerations play a role in shaping consumer attitudes.

The Q6 Frequency results show that 39.8% of respondents rate ethical considerations, as "Very important," and 15.3% rate it as "Extremely important," together accounting for

55.1% of the sample (refer Appendix I, Table 22). Meanwhile, 29.6% find it "Moderately important," while smaller proportions consider it "Slightly important" (10.2%) or "Not at all important" (4.1%) (refer Appendix I, Table 22).

5.2.6 Research Question Testing

5.2.6.1 Factorial Analysis

To address the research question and hypotheses, a factor analysis is conducted to simplify the variables from Q6 into broader, interpretable factors. The original variables include: taste, texture, health benefits, ethical considerations, environmental sustainability, curiosity about new food technologies and packaging.

The descriptive statistics show that taste (M = 4.41) and texture (M = 4.02) are rated the most important variables motivating consumers' interest in PF cheese (refer Appendix J, Table 23). These are followed by health benefits (M = 3.85)**,** environmental sustainability (M = 3.82)**,** and ethical considerations (M = 3.49) (refer Appendix J, Table 23)**.** The lower means for curiosity about new food technologies (M = 2.46) and packaging (M = 2.35) indicate these factors hold less significance to participants (refer Appendix J, Table 23). This is also supported and reflected in the Frequencies of Q6.

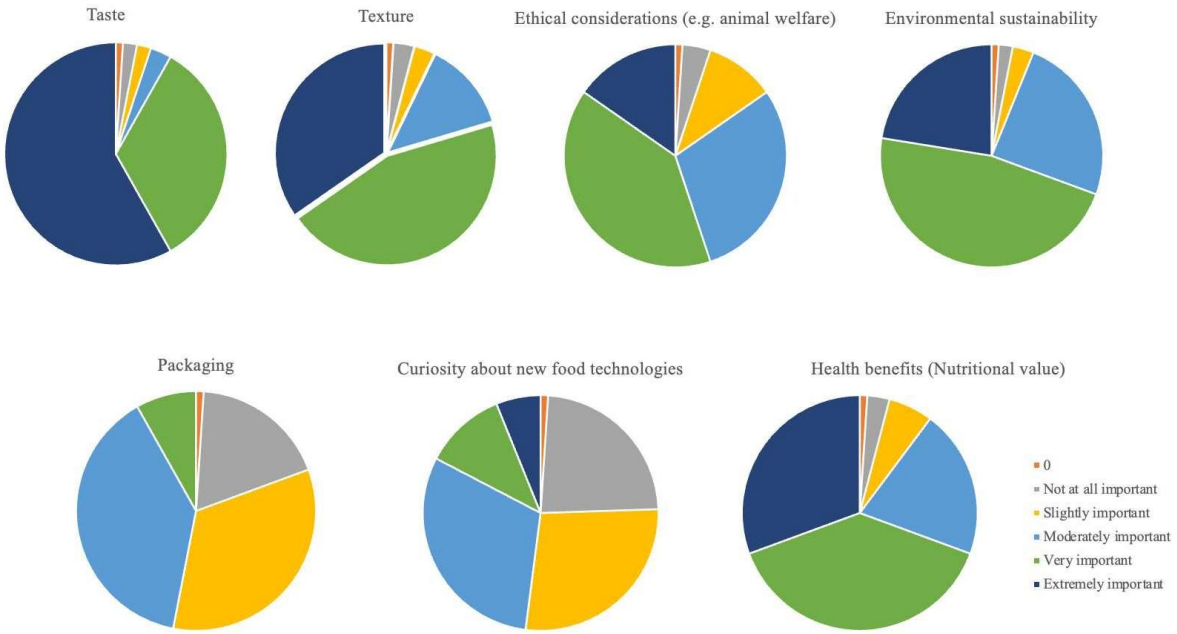

Figure 3: Frequencies of Survey Question 6

The correlation matrix shows a slight positive correlation between taste and texture (Pearson correlation = 0.537)**,** as well as between ethical considerations and environmental sustainability (Pearson correlation = 0.645) (refer Appendix J, Table 24). The remaining variables exhibit weak correlations, with values below 0.5.

To verify the suitability of this factor analysis model, the Kaiser-Meyer-Olkin (KMO) as well as Bartlett's test of sphericity is conducted. The KMO value of 0.602 and a highly significant Bartlett's test of sphericity ($p < 0.01$) confirm the datasets suitability for factor analysis, allowing the rejection of the H that the factors are uncorrelated (Appendix J, Table 25).

The commonalities, which represent the proportion of variance explained by the factor model for each variable, are mostly high. Ethical considerations (0.819) and environmental sustainability (0.791) show strong explained variances (Appendix J, Table 26). Taste (0.791) also has a high communal variance. However, variables such as texture (0.655), packaging (0.682), health benefits (0.544) and curiosity about new food technologies (0.561) have lower communalities variance, indicating that the model explains less of their variances compared to the first group (refer Appendix J, Table 26).

A 3-factor model is selected as it accounts for 69.174% of the total variance contained in the original variables (refer Appendix J, Table 27). These 3 factors account for most of the variance of all the 7 original variables. The first factor, Sensory Appeal, combines taste (0.839) and texture (0.799), demonstrating the significance of sensory characteristics (refer Appendix J, Table 28). The second factor, Sustainability Concerns, incorporates ethical considerations (0.899) and environmental sustainability (0.873), indicating the importance of ethical and environmental values in consumer decision-making (refer Appendix J, Table 28). The third factor, Tech & Packaging Curiosity, includes curiosity about new food technologies (0.730) and packaging (0.810), representing a factor focused on innovation and presentation aspects (refer Appendix J, Table 28).

5.2.6.2 Linear Regression

To test the hypotheses and answer the research question further, a linear regression analysis is conducted. The independent variables are the three factors derived from the factor analysis (Sensory Appeal, Sustainability Concerns and Tech & Packaging Curiosity), all measured on a metric scale. The dependent variable, Q12, representing WTP for PF cheese, is also a variable on a metric scale level.

The regression model explains 9.7% of the variance in the dependent variable ($R^2 = 0.097$) (refer Appendix K, Table 30). This indicates a low level of model fit, as only a small part of the variability in WTP can be attributed to the three factors contained in the model.

The Pearson correlation values among the independent variables are all below 0.8, indicating that there is no sign of multicollinearity (refer Appendix K, Table 29). This ensures that the independent variables have no linear relationship and that their individual contributions to the model can be evaluated reliably.

The ANOVA results show a significant p-value ($p = 0.022$), allowing for the rejection of the H that the factors have no effect on the WTP for PF cheese (refer Appendix K, Table 31). That indicates that at least one of the factors has a statistically significant effect on the WTP.

The coefficient table gives insight to the contribution of each individual factor. Factor 1 (Sensory Appeal) and Factor 3 (Tech & Packaging Curiosity) are not significant predictors, with p-values exceeding 0.05 (refer Appendix K, Table 32). This indicates that these factors have no significant influence on WTP for PF cheese. Factor 2 (Sustainability Concerns) is the only significant predictor, with a p-value of 0.005 (refer Appendix K, Table 32). The unstandardized coefficient ($B = 0.272$) suggests that a one-unit increase in Sustainability Concerns increases the WTP by 0.272 units, while keeping all other variables constant (refer Appendix K, Table 32).

Important to mention is that the assumptions concerning the error term are not violated, ensuring the validity of the regression model (refer Appendix K, Table 33; Table 34; Table 35). Consequently, the findings can be generalized beyond the sample.

5.2.6.3 Cluster Analysis

To explore possible segments within the respondents and in the population, a cluster analysis is conducted to identify distinct consumer groups with different attitudes towards PF cheese, as key variables driving consumers might differ within demographics and might provide deeper insights into market segmentation.

The cluster analysis provides seven distinct clusters, using the previous identified factors where Factor 1 is defined as Sensory Appeal, Factor 2 as Sustainability concerns and Factor 3 as Tech & Packaging Curiosity. Indicated meaningful variations across demographic and behavioral attitudes, such as age, gender, dietary preferences and household income are documented.

For all three factors as well as age, dietary preferences and household income the ANOVA table shows a significance level $p < 0.05$, meaning that the hypotheses that the means are equal can be rejected (refer Appendix L, Table 36). However, gender and WTP did not show significant differences across clusters ($p > 0.05$), suggesting that these variables may not strongly differentiate between groups (refer Appendix L, Table 36).

Cluster 1 is identified as “Sensory-Focused Vegans”. This group consists of older consumers, predominantly female and vegan, who prioritize sensory attributes like taste and texture above all else (refer Appendix L, Table 37).

This group demonstrates the highest interest in the sensory appeal of PF cheese but shows little concern for sustainability or technological curiosity (refer Appendix L, Table 37). They represent a niche market that values premium products with superior sensory qualities, making taste-focused innovations a key driver for acceptance in this segment.

Cluster 2 is described as “Tech-Savy Flexitarians”. It is made up of younger women aged around 26 3 35, who primarily identify as flexitarians (refer Appendix L, Table 37). They are characterized by a strong curiosity about new food technologies, showing the highest mean score for technological and packaging interest (refer Appendix L, Table 37). However, their focus on sustainability is less intense and their sensory preferences are moderate (refer Appendix L, Table 37). Engaging this segment requires emphasizing the innovative nature of PF cheese and its alignment with their exploratory eating habits.

Cluster 3 is called “Disengaged Vegetarians” and includes older vegetarians, mostly female, who show the lowest levels of interest in all three factors (refer Appendix L, Table 37). Their lack of engagement with sensory appeal, sustainability or technology suggests a traditional mindset, possibly satisfied with existing cheese alternatives (refer Appendix L, Table 37). This segment may be less receptive to marketing efforts focused on innovation or ethics and could require targeted education to spark interest.

Cluster 4 are the “Sustainability-Focused Omnivores”. This cluster consists of males aged 26 3 36 years old who identify as omnivores (refer Appendix L, Table 37). They stand out for their high concern for sustainability and ethical attributes, scoring the highest on this factor (refer Appendix L, Table 37). However, their interest in sensory appeal and technological innovation is moderate to negative (refer Appendix L, Table 37). This group represents a critical opportunity to highlight the environmental benefits of PF cheese in communications, particularly in terms of reducing greenhouse gas emissions and improving animal welfare.

Cluster 5, the “Ethical Young Omnivores”, includes young women aged 20330 who are omnivores (refer Appendix L, Table 37). They place moderate importance on sustainability concerns while showing little interest in sensory appeal or technological curiosity (refer Appendix L, Table 37). This group values ethical considerations but may require convincing on the sensory and innovative benefits of the product (refer Appendix L, Table 37). Clear messaging around ethical production and sustainability could resonate well with this segment.

The so called “Young Vegan Innovators” in Cluster 6 represent young female vegans in their early 20s (refer Appendix L, Table 37). They are curious about new technologies and display moderate

concern for sustainability, although their sensory preferences are somewhat lower (refer Appendix L, Table 37). This group is open to innovation and represents an experimental segment that is likely to adopt PF cheese if the product aligns with their ethical and technological values.

Finally, the “Sensory-Oriented Male Omnivores” in Cluster 7 include young male omnivores in their early 20s, who prioritize sensory appeal but show low interest in sustainability or technology (refer Appendix L, Table 37). This segment has the second-highest score for sensory attributes and could be drawn to the product based on its taste and texture (refer Appendix L, Table 37). Marketing efforts targeting this group should emphasize the ability of PF cheese to replicate the sensory qualities of traditional cheese.

The cluster analysis reveals varying segment sizes, ranging from small, niche groups to larger ones. Cluster 5, the "Ethical Young Omnivores," is the largest group with 33 individuals, while Cluster 3, the "Disengaged Vegetarians," is the smallest with only 2 respondents (refer Appendix L, Table 38). Clusters 2 and 4, represent "Tech-Savvy Flexitarians" and "Sustainability-Focused Omnivores" and are moderately sized with 21 and 19 members (refer Appendix L, Table 38). The remaining clusters, including "Sensory-Focused Vegans," "Young Vegan Innovators," and "Sensory-Oriented Male Omnivores," range from 4 to 11 members each, reflecting their more specific consumer profiles (refer Appendix L, Table 38). This variation reflects the diversity of attitudes and motivations towards PF cheese, highlighting distinct opportunities for tailored communication strategies.

6. Discussion

6.1 Analysis and Interpretation

Hypothesis 01

The results consistently demonstrate that taste is a critical attribute of consumer acceptance and WTP for PF cheese. This research’s survey data indicates that 91.9% of respondents rated taste as either "Very important" or "Extremely important," underlining its vital role (refer Appendix E, Table 11). Similarly, qualitative insights highlight significant dissatisfaction with the taste of existing cheese alternatives, often described as "artificial" or "plastic-like= (refer Appendix B). This aligns with prior research suggesting that sensory qualities are primary motivators for food product acceptance. However, regression analysis indicates that taste alone does not significantly predict WTP, suggesting that while essential, it must be combined with other factors to drive premium pricing.

Hypothesis 02

Texture also emerges as a driver, with 79.6% of respondents rating it as highly important (refer Appendix E, Table 12). Issues such as the inability of vegan cheese to melt properly were frequently cited during interviews, reinforcing its importance for culinary functionality (refer Appendix B).

Quantitative results align with these findings, though, like taste, texture's predictive power individually on WTP remains inconclusive. This suggests that addressing texture deficiencies is a necessary but insufficient condition for market success.

Hypothesis 03

Environmental sustainability resonates strongly with participants, with nearly 70% identifying it as a highly relevant motivator (refer Appendix F, Table 14). This aligns with broader consumer trends favoring eco-friendly products. Regression results confirm that sustainability concerns significantly influence WTP, with a 0.272-unit increase for every unit rise in perceived environmental benefits (refer Appendix K, Table 32). These findings emphasize the importance of transparent and convincing communication about the lower greenhouse gas emissions associated with PF cheese.

Hypothesis 04

Health-related messaging has a notable impact, as reflected by 74.5% of respondents indicating that detailed health information drives confidence in purchasing decisions (refer Appendix G, Table 15). Interviewees also expressed interest in cleaner labels (refer Appendix B). While regression analysis does not directly support a significant impact on WTP, the high interest supports the need for targeted messaging to influence health-conscious consumer segments.

Hypothesis 05

Transparency in production processes is a key trust-building measure, with 70.4% of respondents identifying it as critical for confidence (refer Appendix H, Table 18). Interviews revealed concerns about genetic modification, highlighting a gap in consumer understanding (refer Appendix B). The regression analysis does not establish a direct link between production process transparency and WTP suggesting it must be contextualized within broader communication strategies.

Hypothesis 06

Ethical considerations play a meaningful role in consumer decision-making as well as approximately 55.1% of respondents rated ethical concerns as very or extremely important (refer Appendix I, Table 22). Qualitative insights support this, with participants frequently associating PF with reduced animal suffering (refer Appendix B). Factor analysis reinforces the weight of ethical considerations, which are closely linked with sustainability in shaping consumer preferences.

Overall Research Question

The study's findings reveal that Sensory Appeal (taste and texture), sustainability, and ethical considerations are the most influential factors in shaping WTP for PF cheese. Among these, sustainability demonstrates the strongest predictive power. However, low overall explanatory power (R^2 = 9.7%) of the regression model suggests additional variables, such as cultural influences or marketing effectiveness, remain unexamined (refer Appendix K, Table 30).

6.2 Managerial Implications

Managers should prioritize Sensory Appeal by investing in research and development to enhance taste and texture. Collaborating with food scientists to address the melting and mouthfeel deficiencies identified by participants and conducting sensory testing through focus groups can ensure alignment with consumer expectations. Sustainability messaging should be leveraged through marketing campaigns that emphasize the reduced environmental footprint of PF cheese, supported by specific metrics such as greenhouse gas reductions and validated by partnerships with sustainability certification bodies. Ethical benefits should also be highlighted, integrating animal welfare messaging into branding with clarity and relatability while engaging influencers or organizations advocating for ethical consumption to amplify the reach.

Transparency should be enhanced by developing educational materials that explain the PF process in simple and understandable terms, addressing misconceptions about genetic modification, and for example including QR codes on packaging linking to detailed videos or infographics about the production process. Managers should target diverse consumer segments by designing tailored messaging for distinct market segments identified through cluster analysis. For example, emphasizing innovation and functionality for tech-savvy flexitarians, highlighting sensory appeal for sensory-focused omnivores and vegans, and highlighting sustainability and ethics for environmentally conscious consumers.

Educating and building trust is essential. This can be achieved by conducting workshops, webinars, or tasting events to familiarize consumers with the product and address concerns about safety and naturalness. Partnering with trusted organizations to validate claims and enhance consumer confidence can be a further driver for this effort.

From a policy and advocacy perspective, engaging regulators to advocate for updated labeling laws that allow PF products to be described as "cheese" will ensure clarity without compromising legal standards. Collaborating with academic institutions for studies on the environmental and health impacts of PF products can generate robust, independent data. Additionally, promoting industry standards by establishing standardized sustainability and ethical benchmarks for PF products can align industry practices and enhance consumer trust.

Although the exact attributes influencing WTP for PF cheese were not fully determined, this research identified several potential factors that could shape consumer preferences. For future research and marketing strategies, segmenting the market based on distinct consumer profiles and communication needs appears to be a promising approach. Tailored messaging and targeted interventions

are essential to address diverse consumer expectations, enhance understanding, and foster trust in this innovative product category.

6.3 Further Research

Building on the limitations of this study, several ways for further research are possible. First, future studies could incorporate a larger, more diverse sample that better represents the German population. This would include a broader range of socioeconomic backgrounds, geographic locations, and dietary habits to ensure the findings are more generalizable and reflective of diverse consumer preferences.
Second, the inclusion of longitudinal studies could provide a deeper understanding of how consumer attitudes toward PF cheese evolve over time. Tracking changes in WTP, perceptions of sustainability, health benefits, and ethical considerations over several months or years could yield more robust insights into long-term market trends and adoption rates.
Third, more detailed and targeted survey designs should be considered. Surveys that include comprehensive, attribute-based questions can explore specific drivers of WTP more thoroughly. For example, questions could isolate the influence of taste, texture, or transparency about production methods, allowing researchers to disentangle these variables more effectively.
Finally, exploring the sensory attributes of PF cheese through controlled experimental studies would also be valuable. Testing prototypes with focus groups or using blind taste tests could assess the product's performance against traditional cheese and other alternatives, addressing consumer concerns about taste and texture.
By addressing these areas, future research can build on the foundations laid by this study, offering deeper, more actionable insights into the consumer acceptance and market potential of PF cheese.

6.4 Limitations

This research study encounters several notable limitations. The qualitative research is limited by a small sample size of 10 participants, which may not adequately represent the German population. This limited sample potentially leads to confirmation bias and social desirability bias, as many participants are acquainted with the interviewer.
Demographic representation poses a major challenge. Although age ranges from 21 to 72 years, other important demographic factors, such as socioeconomic background, urban or rural residence, and occupation, are not sufficiently considered. These missing factors may affect the completeness of the results.

In the quantitative research phase, several challenges arise. The regression model demonstrates a low explanatory power, with an R^2 value of only 9.7% (refer Appendix K, Table 30). This suggests that other significant variables influencing WTP, such as for example cultural attitudes or perceived brand trust, are not captured. Additionally, the study might be subjected to the attitudinal-behavioral gap, a well-documented phenomenon where participants express a preference for sustainability in surveys but may not reflect this in real-world purchasing behaviour. This possible dissonance between stated and actual preferences may skew results and limit the accuracy of findings.

The survey design itself could be more comprehensive, both in terms of sample size and the level of detail in questions. Including a larger number of respondents would increase the generalizability of the findings, while more detailed questions for each attribute could provide deeper insights into the factors influencing WTP. The lack of randomization in sample selection further limits the generalizability of the results, and the sample overrepresented younger, female, student populations with academic backgrounds, which may skew certain findings, particularly regarding environmental and ethical considerations.

Time constraints also significantly impact the scope of the study. With only a few weeks available for data collection and analysis, the depth of the investigation is compromised. Furthermore, the online distribution method excludes individuals without internet access, creating a potential bias in the data. Language barriers among some participants may further affect response quality.

Despite these limitations, the study offers valuable insights into consumer attitudes and preferences while highlighting areas for improvement in future research. Expanding sample diversity, refining survey design with detailed attribute-based questions, and addressing unaccounted variables could provide a more comprehensive understanding of PF cheese adoption.

7. Conclusion

The exploration of PF cheese as a new sustainable food innovation reveals a complex relationship of factors that influence consumer acceptance. At its core, the study highlights sensory appeal (taste and texture) as critical determinants of WTP. While consumers are drawn to the environmental and ethical benefits of PF, these attributes alone cannot overcome shortcomings in sensory experience. This finding reinforces the need for product development that prioritizes authenticity and culinary versatility to bridge the gap between innovation and tradition.

Sustainability emerges as a significant motivator, particularly in the German market, where environmental consciousness is deeply entrenched. Consumers demonstrate a strong preference for products that align with their values of reducing greenhouse gas emissions and promoting

animal welfare. However, the study also highlights the importance of effective communication in translating these values into purchasing decisions. Transparency about the production process, coupled with clear labeling and educational initiatives, can decimate concerns about the perceived unnaturalness of PF and build consumer trust.

Ethical considerations, while closely linked to sustainability, resonate deeply with segments that prioritize animal welfare and ethical consumption. The study's findings suggest that framing PF cheese as a humane alternative to traditional dairy can appeal to a growing demographic of ethically minded consumers. Nevertheless, barriers such as skepticism toward genetic modification and novelty of the technology remain, requiring targeted efforts to normalize these products.

The segmentation analysis offers valuable insights into the diversity of consumer profiles, from sensory-focused omnivores to tech-savvy flexitarians. These distinct groups highlight the need for tailored marketing strategies that address the unique priorities and concerns of each segment. For example, emphasizing innovation and functionality may resonate with younger, experimental consumers, while older, traditional segments may require reassurance about sensory quality and safety.

This thesis also highlights broader implications for the food industry. PF represents a convergence of technology and sustainability, challenging conventional paradigms and creating opportunities for innovation. Its success depends not only on scientific advancements but also on the industry's ability to foster trust and engagement with consumers. By positioning PF cheese as both a high-quality culinary product and a responsible choice for the planet, companies can navigate the complexities of this emerging market.

Ultimately, the study contributes to a growing body of knowledge on the intersection of consumer behavior and sustainable food technologies. It emphasizes the need for a multi-faceted approach that integrates sensory excellence, ethical transparency, and strategic communication. As the global food landscape evolves, PF has the potential to redefine dairy consumption, offering a vision of indulgence that aligns with a sustainable future. The journey toward this vision, however, requires careful management, based on an understanding of the human dimensions that influence our decisions.

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APPENDIX A: Interview Guide – Qualitative Research

Introduction
Thank you for agreeing to participate in this interview. The purpose of this discussion is to better understand consumer attitudes and perceptions regarding cheese alternatives. Your responses will remain anonymous. Please feel free to share your thoughts openly. The interview should take about 15330 minutes.

Demographics
Can you tell me about yourself? (Age, where do you live, do you work?)

Dietary Habits
Do you have a special diet? (Vegan, flexitarian, vegetarian, omnivore, etc.)
What type of dietary preferences or restrictions do you follow? (Vegan, flexitarian, vegetarian, omnivore, etc.

Experiences with Cheese Alternatives
Have you ever bought a cheese alternative before?
Do you remember what kind of cheese it was?
What aspects did you like about it?
What aspects did you dislike about it?
What motivated you to buy that cheese alternative?

+++ Introduction to Precision Fermentation +++
Have you heard of precision fermentation before?
(Interviewer explanation: Precision fermentation involves changing the DNA of organisms, which opens opportunities to produce bioidentical milk proteins without any cows or other dairy animals. This allows the creation of almost any type of cheese, free of antibiotics, lactose, and hormones.)

Perceptions of Precision Fermentation
What are your initial thoughts on it?
How do you feel about the use of genetic modification in food production?
Does it impact your interest in trying new products?

Openness to Food Technology
Are you open to trying new food technologies? Why or why not?
Have you ever eaten precision fermentation food?

Information Needs
What information about precision fermentation would you need to feel confident in purchasing this type of product?
What information or messages do you think would help consumers feel more informed and comfortable about precision fermentation cheese?

Willingness to pay for Innovative Products
Are you generally willing to pay more for food products that represent innovation?

End
Thank you so much for sharing your thoughts and experiences.

APPENDIX B: Summary of Interviews

Interviewee No. 01:
Interviewee No.01 is a vegetarian student from Berlin who has limited awareness of precision fermentation but expresses curiosity and openness to try innovative products. She emphasizes the importance of replicating the taste and simplicity of traditional cheese without excessive additives, which she dislikes in current vegan alternatives. While neutral on genetic modification, she notes that transparency and understanding the technology would influence her decision to try such products.

Interviewee No. 02:
Interviewee No.02, a pescatarian living in Berlin, finds the texture and taste of current cheese alternatives unsatisfactory, describing them as "plastic-like." She expressed interest in precision fermentation but emphasized the need for these products to closely replicate traditional cheese, particularly in consistency and melting properties. While she appreciated sustainability, taste remained her top priority.

Interviewee No. 03:
Interviewee No. 03, a 21-year-old student nearby Munich, has no prior experience with cheese alternatives but is familiar with meat substitutes. He appreciates the environmental benefits of precision fermentation but notes that unfamiliarity with the technology might hinder his willingness to try it. Taste and protein content are critical factors in his acceptance of food innovations.

Interviewee No. 04:
Interviewee No. 04, a vegetarian from Munich, is motivated by ethical and environmental concerns to explore cheese alternatives. However, she finds current alternatives lacking in functionality, particularly in melting properties, which hinders her full transition away from traditional cheese. She views precision fermentation as a promising solution aligned with her values but emphasizes the need for proof of safety and taste authenticity.

Interviewee No. 05:
Interviewee No. 05, a recruiter and beer garden owner from Berlin, has heard of precision fermentation but is skeptical about its necessity given the availability of traditional and lactose-free cheeses. He expresses curiosity about trying new food technologies but preferres products that taste natural and are not overtly marketed as genetically modified. Taste is his primary consideration for purchasing decisions.

Interviewee No. 06:
Interviewee No. 06, an omnivore from Berlin reducing her dairy consumption, has concerns about the additives in conventional cheese alternatives and prefers clean-label products. She is in fact familiar with precision fermentation and views it as an ethical and sustainable innovation but highlights the need for consumer education. Her purchasing decisions are influenced by product packaging, ingredient transparency, and environmental impact.

Interviewee No. 07:
Interviewee No.07, a 46-year-old omnivore from Munich, has no experience with cheese or meat substitutes and is uninterested in adopting alternatives. He is open to trying products in social settings but found the taste and texture of substitutes unsatisfactory compared to traditional options.

While he acknowledges the environmental benefits of innovations like precision fermentation, they are not a priority for him.

Interviewee No. 08:
Interviewee No.08, a flexible omnivore living in Berlin, views precision fermentation as a potential ethical solution for non-dairy cheese. However, she questions its necessity for individuals satisfied with traditional dairy, noting that she would prioritize transparency about the technology's environmental and health impacts. Although sustainability and ethical production are important considerations for her, she remained cautious about overly processed alternatives.

Interviewee No. 09:
Interviewee No. 09, a student from Berlin and former vegan, has experience with various cheese alternatives and appreciates the simplicity of precision fermentation. She expresses enthusiasm for its disruptive potential, particularly its alignment with ethical and environmental values. However, she emphasizes the need for education around genetic modification to address potential consumer skepticism.

Interviewee No. 10:
Interviewee No. 10, a vegetarian student living in Munich, finds most cheese alternatives unappealing due to artificial taste and poor texture. She views precision fermentation as "scary but interesting" and expresses a willingness to try it, if its benefits are transparently communicated. Animal welfare and sustainability are her primary motivations for exploring alternatives, though taste remains a critical factor in her purchasing decisions.

APPENDIX C: SAMPLE

Table 1: Frequencies of Age

Age of participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Under 25	28	28,6	28,6	28,6
	25-35	55	56,1	56,1	84,7
	36-45	6	6,1	6,1	90,8
	46-55	5	5,1	5,1	95,9
	Over 55	4	4,1	4,1	100,0
	Total	98	100,0	100,0	

Table 2: Frequencies of Gender

Please specify your gender.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	41	41,8	41,8	41,8
	Female	57	58,2	58,2	100,0
	Total	98	100,0	100,0	

Table 3: Frequencies of dietary preferences

What type of dietary preferences or restrictions do you follow?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Flexitarian	20	20,4	20,4	20,4
	Omnivore (I eat everything)	52	53,1	53,1	73,5
	Vegetarian	13	13,3	13,3	86,7
	Vegan	5	5,1	5,1	91,8
	Pescatarian	6	6,1	6,1	98,0
	Other	2	2,0	2,0	100,0
	Total	98	100,0	100,0	

Table 4: Frequencies income

Please select your approximate annual household gross income per year.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below ¬20,000	25	25,5	25,5	25,5
	¬20,001 - ¬40,000	20	20,4	20,4	45,9
	¬40,001 - ¬60,000	20	20,4	20,4	66,3
	¬60,000 - ¬80,000	9	9,2	9,2	75,5
	Above ¬80,000	18	18,4	18,4	93,9
	Prefer not to respond	6	6,1	6,1	100,0
	Total	98	100,0	100,0	

Table 5: Frequencies Occupational situation

What is your current occupational situation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Employed	50	51,0	51,0	51,0
	Self-employed	9	9,2	9,2	60,2
	Apprenticeship	1	1,0	1,0	61,2
	Studying	34	34,7	34,7	95,9
	Other	4	4,1	4,1	100,0
	Total	98	100,0	100,0	

APPENDIX D: QUANTITATIVE RESEARCH

Table 6: Linear Regression Q6 and Q12. ANOVA

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11,654	7	1,665	1,916	,076[b]
	Residual	78,193	90	,869		
	Total	89,847	97			

a. Dependent Variable: How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?

b. Predictors: (Constant), Packaging, Texture, Ethical considerations (e.g. animal welfare), Health benefits (Nutritional value), Curiosity about new food technologies, - Environmental sustainability, Taste

Table 7: Linear Regression Q6 and Q12. Correlations

Correlations

		How much would you be WTP for pf cheese compared to traditional cheese?	Texture	Ethical considerations (e.g. animal welfare)	Environmental sustainability	Health benefits (Nutritional value)	Curiosity about new food technologies	Packaging
Pearson Correlation	How much would you be WTP for pf cheese compared to traditional cheese?	1,000	-,138	,302	,184	-,062	,044	-,068
	Taste	-,014	,537	,261	,314	,425	,136	,255
	Texture	-,138	1,000	,094	,120	,179	,129	,081
	Ethical considerations (e.g. animal welfare)	,302	,094	1,000	,645	-,006	,172	,121
	cheese? - Environmental sustainability	,184	,120	,645	1,000	,072	,140	,157
	Health benefits (Nutritional value)	-,062	,179	-,006	,072	1,000	,104	,294
	Curiosity about new food technologies	,044	,129	,172	,140	,104	1,000	,312
	Packaging	-,068	,081	,121	,157	,294	,312	1,000

APPENDIX E: HYPOTHESES 01 & 02 TESTING

Table 8: Hypotheses 01 & 02 Testing: Descriptive Statistics Q7

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Taste	98	0	1	,73	,444
Texture	98	0	1	,36	,482
Health	98	0	1	,49	,502
Safety	98	0	1	,38	,487
Association with genetic modification	98	0	1	,29	,454
Price	98	0	1	,37	,485
Lack of information about the production process	98	0	1	,32	,467
Other	98	0	1	,02	,142
Valid N (listwise)	98				

Table 9: Hypotheses 01 & 02 Testing: Frequencies Q8

How likely are you to try precision fermentation cheese if it tastes similar to traditional cheese?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely unlikely	2	2,0	2,0	2,0
	Somewhat unlikely	5	5,1	5,1	7,1
	Neither likely nor unlikely	4	4,1	4,1	11,2
	Somewhat likely	50	51,0	51,0	62,2
	Extremely likely	37	37,8	37,8	100,0
	Total	98	100,0	100,0	

Table 10: Hypotheses 01 & 02 Testing: Frequencies Q13

How likely are you to recommend precision fermentation cheese to others if you found it satisfactory in taste and texture?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely unlikely	3	3,1	3,1	3,1
	Somewhat unlikely	3	3,1	3,1	6,1
	Neither likely nor unlikely	8	8,2	8,2	14,3
	Somewhat likely	55	56,1	56,1	70,4
	Extremely likely	29	29,6	29,6	100,0
	Total	98	100,0	100,0	

Table 11: Hypotheses 01 & 02 Testing: Frequencies Q6 - Taste

How important are the following factors in motivating you to try precision fermentation cheese? - Taste

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	1,0	1,0	1,0
	Not at all important	2	2,0	2,0	3,1
	Slightly important	2	2,0	2,0	5,1
	Moderately important	3	3,1	3,1	8,2
	Very important	33	33,7	33,7	41,8
	Extremely important	57	58,2	58,2	100,0
	Total	98	100,0	100,0	

Table 12: Hypotheses 01 & 02 Testing: Frequencies Q6 – Texture

How important are the following factors in motivating you to try precision fermentation cheese? - Texture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	1,0	1,0	1,0
	Not at all important	3	3,1	3,1	4,1
	Slightly important	3	3,1	3,1	7,1
	Moderately important	13	13,3	13,3	20,4
	Very important	44	44,9	44,9	65,3
	Extremely important	34	34,7	34,7	100,0
	Total	98	100,0	100,0	

APPENDIX F: HYPOTHESES 03 TESTING

Table 13: Hypotheses 03 Testing: Frequencies Q10 – Environmental impact

What type of information would make you feel more confident about purchasing precision fermentation cheese? (Select all that apply) Details on environmental impact

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	58	59,2	59,2	59,2
	Details on environmental impact	40	40,8	40,8	100,0
	Total	98	100,0	100,0	

Table 14: Hypotheses 03 Testing: Frequencies Q6 – Environmental sustainability

How important are the following factors in motivating you to try precision fermentation cheese? - Environmental sustainability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	1,0	1,0	1,0
	Not at all important	2	2,0	2,0	3,1
	Slightly important	3	3,1	3,1	6,1
	Moderately important	24	24,5	24,5	30,6
	Very important	46	46,9	46,9	77,6
	Extremely important	22	22,4	22,4	100,0
	Total	98	100,0	100,0	

APPENDIX G: HYPOTHESES 04 TESTING

Table 15: Hypotheses 04 Testing: Frequencies 10 - Health

What type of information would make you feel more confident about purchasing precision fermentation cheese? (Select all that apply) Details on health

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	25	25,5	25,5	25,5
	Details on health	73	74,5	74,5	100,0
	Total	98	100,0	100,0	

Table 16: Hypotheses 04 Testing: Q6 Frequencies – Health benefits

How important are the following factors in motivating you to try precision fermentation cheese? - Health benefits (Nutritional value)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	1,0	1,0	1,0
	Not at all important	3	3,1	3,1	4,1
	Slightly important	6	6,1	6,1	10,2
	Moderately important	20	20,4	20,4	30,6
	Very important	38	38,8	38,8	69,4
	Extremely important	30	30,6	30,6	100,0
	Total	98	100,0	100,0	

Table 17: Hypotheses 04 Testing: Frequencies Q7 – Health

What are your primary concerns about precision fermentation cheese? - Selected Choice Health

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	50	51,0	51,0	51,0
	Health	48	49,0	49,0	100,0
	Total	98	100,0	100,0	

APPENDIX H: HYPOTHESES 05 TESTING

Table 18: Hypotheses 05 Testing. Frequencies Q10 – Explanation of production process

What type of information would make you feel more confident about purchasing precision fermentation cheese? (Select all that apply) Explanation of the production process

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	29	29,6	29,6	29,6
	Explanation of the production process	69	70,4	70,4	100,0
	Total	98	100,0	100,0	

Table 19: Hypotheses 05 Testing: Linear Regression Q10 and Q12

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8,877	5	1,775	2,017	,083[b]
	Residual	80,970	92	,880		
	Total	89,847	97			

a. Dependent Variable: How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?

b. Predictors: (Constant), What type of information would make you feel more confident about purchasing precision fermentation cheese?
(Select all that apply) Consumer reviews and testimonials, What type of information would make you feel more confident about purchasing precision fermentation cheese?
(Select all that apply) Details on health, What type of information would make you feel more confident about purchasing precision fermentation cheese?
(Select all that apply) Explanation of the production process, What type of information would make you feel more confident about purchasing precision fermentation cheese?
(Select all that apply) Details on environmental impact, What type of information would make you feel more confident about purchasing precision fermentation cheese?
(Select all that apply) Certification from trusted organizations

Table 20: Hypotheses 05 Testing: Frequencies Q6 – Curiosity about new food technologies

How important are the following factors in motivating you to try precision fermentation cheese? - Curiosity about new food technologies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	1,0	1,0	1,0
	Not at all important	23	23,5	23,5	24,5
	Slightly important	27	27,6	27,6	52,0
	Moderately important	30	30,6	30,6	82,7
	Very important	11	11,2	11,2	93,9
	Extremely important	6	6,1	6,1	100,0
	Total	98	100,0	100,0	

APPENDIX I: HYPOTHESES 06 TESTING

Table 21: Hypotheses 06 Testing: Frequencies Q10 – Certification from trusted organizations

What type of information would make you feel more confident about purchasing precision fermentation cheese? (Select all that apply) Certification from trusted organizations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	31	31,6	31,6	31,6
	Certification from trusted organizations	67	68,4	68,4	100,0
	Total	98	100,0	100,0	

Table 22: Hypotheses 06 Testing: Frequencies Q6 – Ethical considerations

How important are the following factors in motivating you to try precision fermentation cheese? - Ethical considerations (e.g. animal welfare)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	1,0	1,0	1,0
	Not at all important	4	4,1	4,1	5,1
	Slightly important	10	10,2	10,2	15,3
	Moderately important	29	29,6	29,6	44,9
	Very important	39	39,8	39,8	84,7
	Extremely important	15	15,3	15,3	100,0
	Total	98	100,0	100,0	

APPENDIX J: RESEARCH QUESTION TESTING - FACTOR ANALYSIS

Table 23: Research Question Testing. Factor Analysis. Descriptives

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
Taste	4,41	,940	98
Texture	4,02	1,025	98
Ethical considerations (e.g. animal welfare)	3,49	1,067	98
Environmental sustainability	3,82	,956	98
Health benefits (Nutritional value)	3,85	1,087	98
Curiosity about new food technologies	2,46	1,177	98
Packaging	2,35	,909	98

Table 24: Research Question Testing. Factor Analysis. Correlation Matrix

Correlation Matrix

	Correlation						
	Taste	Texture	Ethical considerations (e.g. animal welfare)	Environmental sustainability	Health benefits (Nutritional value)	Curiosity about new food technologies	Packaging
Taste	1,000	,537	,261	,314	,425	,136	,255
Texture	,537	1,000	,094	,120	,179	,129	,081
Ethical considerations (e.g. animal welfare)	,261	,094	1,000	,645	-,006	,172	,121
Environmental sustainability	,314	,120	,645	1,000	,072	,140	,157
Health benefits (Nutritional value)	,425	,179	-,006	,072	1,000	,104	,294
Curiosity about new food technologies	,136	,129	,172	,140	,104	1,000	,312
- Packaging	,255	,081	,121	,157	,294	,312	1,000

Table 25: Research Question Testing. Factor Analysis. KMO and Bartlett9s Test

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,602
Bartlett's Test of Sphericity	Approx. Chi-Square	138,437
	df	21
	Sig.	<,001

Table 26: Research Question Testing. Factor Analysis. Communalities

Communalities

	Initial	Extraction
Taste	1,000	,791
Texture	1,000	,655
Ethical considerations (e.g. animal welfare)	1,000	,819
Environmental sustainability	1,000	,791
Health benefits (Nutritional value)	1,000	,544
Curiosity about new food technologies	1,000	,561
Packaging	1,000	,682

Extraction Method: Principal Component Analysis.

Table 27: Research Question Testing. Factor Analysis. Total Variance Explained

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,350	33,567	33,567	2,350	33,567	33,567	1,742	24,884	24,884
2	1,382	19,749	53,316	1,382	19,749	53,316	1,700	24,291	49,176
3	1,110	15,858	69,174	1,110	15,858	69,174	1,400	19,998	69,174
4	,855	12,214	81,388						
5	,599	8,556	89,944						
6	,356	5,089	95,033						
7	,348	4,967	100,000						

Extraction Method: Principal Component Analysis.

Table 28: Research Question Testing. Factor Analysis. Rotated Component Matrix

Rotated Component Matrix[a]

	Component		
	1	2	3
Taste	,839	,257	,143
Texture	,799	,090	-,088
Ethical considerations (e.g. animal welfare)	,049	,899	,090
Environmental sustainability	,136	,873	,103
Health benefits (Nutritional value)	,594	-,165	,405
Curiosity about new food technologies	-,017	,165	,730
Packaging	,157	,045	,810

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 5 iterations.

APPENDIX K: RESEARCH QUESTION TESTING - LINEAR REGRESSION

Table 29: Research Question Testing. Linear Regression. Correlations

Correlations

		How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?	REGR factor score 1 for analysis 1	REGR factor score 2 for analysis 1	REGR factor score 3 for analysis 1
Pearson Correlation	How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?	1,000	-,129	,283	-,013
	REGR factor score 1 for analysis 1	-,129	1,000	,000	,000
	REGR factor score 2 for analysis 1	,283	,000	1,000	,000
	REGR factor score 3 for analysis 1	-,013	,000	,000	1,000

Table 30: Research Question Testing. Linear Regression. Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,311[a]	,097	,068	,929	1,900

a. Predictors: (Constant), REGR factor score 3 for analysis 1, REGR factor score 2 for analysis 1, REGR factor score 1 for analysis 1

b. Dependent Variable: How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?

Table 31: Research Question Testing. Linear Regression. ANOVA

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8,705	3	2,902	3,361	,022[b]
	Residual	81,142	94	,863		
	Total	89,847	97			

a. Dependent Variable: How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?

b. Predictors: (Constant), REGR factor score 3 for analysis 1, REGR factor score 2 for analysis 1, REGR factor score 1 for analysis 1

Table 32: Research Question Testing. Linear Regression. Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	2,582	,094		27,507	<,001		
	REGR factor score 1 for analysis 1	-,125	,094	-,129	-1,321	,190	1,000	1,000
	REGR factor score 2 for analysis 1	,272	,094	,283	2,885	,005	1,000	1,000
	REGR factor score 3 for analysis 1	-,013	,094	-,013	-,137	,891	1,000	1,000

a. Dependent Variable: How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?

Table 33: Research Question Testing. Linear Regression. Histogram

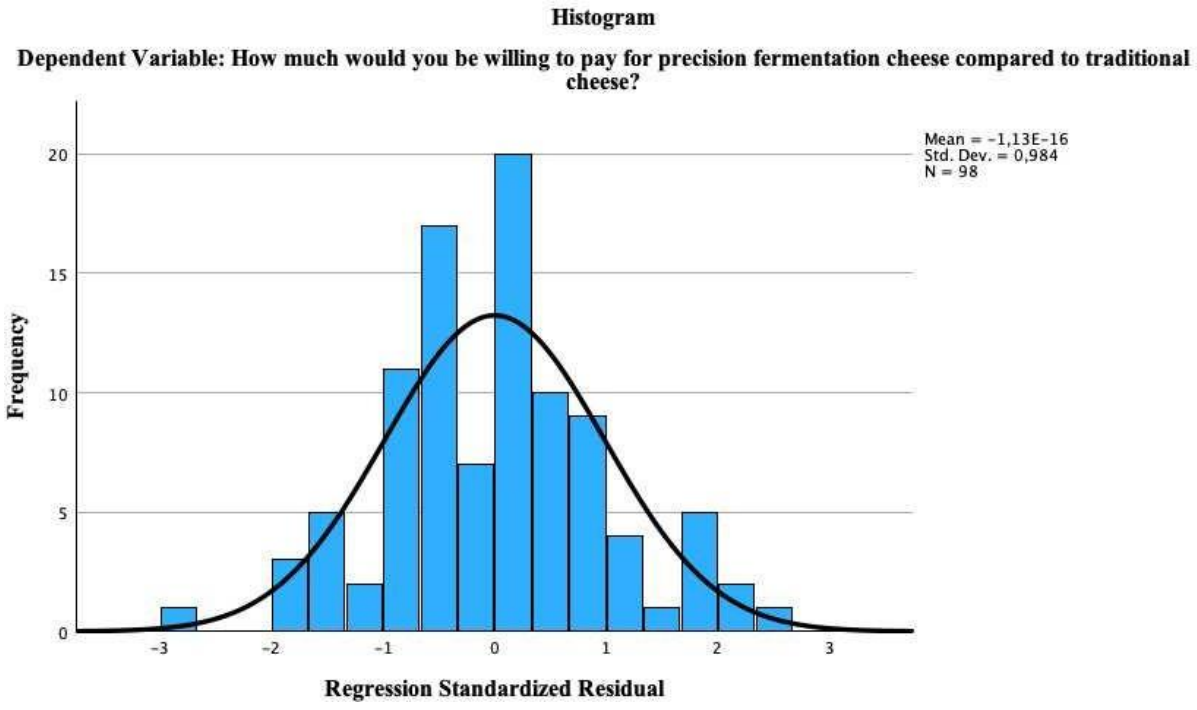


Table 34: Research Question Testing. Linear Regression.

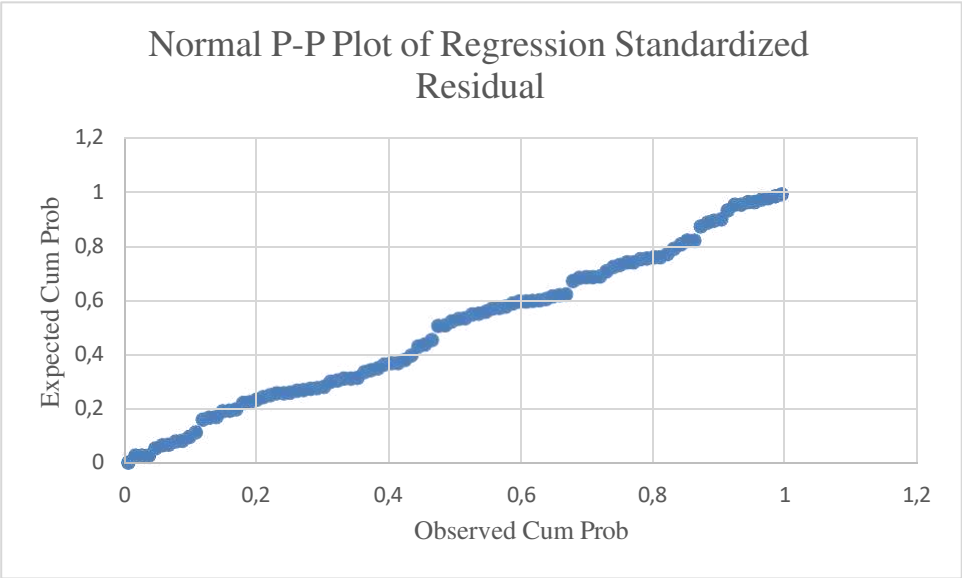
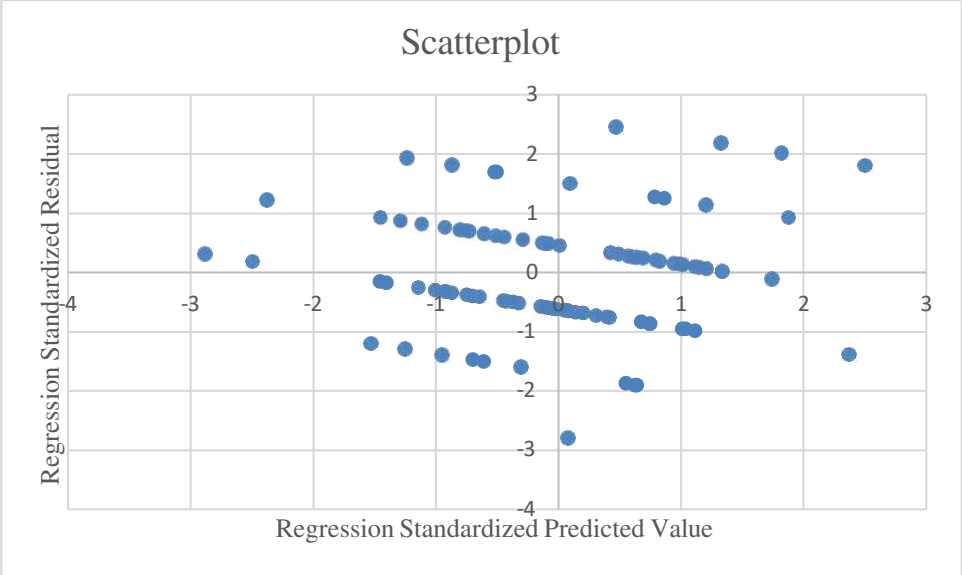


Table 35: Research Question Testing. Linear Regression. Scatterplot



APPENDIX L: RESEARCH QUESTION TESTING - CLUSTER ANALYSIS

Table 36: Research Question Testing. Cluster Analysis - ANOVA

ANOVA

	Cluster		Error			
	Mean Square	df	Mean Square	df	F	Sig.
Age of participants	7,190	6	,515	91	13,964	<,001
Please specify your gender.	,310	6	,242	91	1,281	,274
What type of dietary preferences or restrictions do you follow?	13,076	6	,571	91	22,900	<,001
Please select your approximate annual household gross income per year.	36,360	6	,399	91	91,053	<,001
How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?	2,341	6	,833	91	2,810	,015
REGR factor score 1 for analysis 1	5,616	6	,696	91	8,073	<,001
REGR factor score 2 for analysis 1	7,070	6	,600	91	11,787	<,001
REGR factor score 3 for analysis 1	7,725	6	,557	91	13,880	<,001

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

Table 37: Research Question Testing. Cluster Analysis – Final Cluster Centers

Final Cluster Centers

	Cluster						
	1	2	3	4	5	6	7
Age of participants	4,50	2,24	3,50	2,26	1,45	1,73	1,75
Please specify your gender.	2	2	2	1	2	2	1
What type of dietary preferences or restrictions do you follow?	4	1	3	2	2	4	2
Please select your approximate annual household gross income per year.	6	3	3	5	1	3	5
How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?	3	2	2	3	3	3	2
REGR factor score 1 for analysis 1	1,27357	,02072	-2,08073	-,47327	,04528	-,36181	1,26373
REGR factor score 2 for analysis 1	-,74246	-,47922	-3,43666	,58237	,35770	,00072	-,37127
REGR factor score 3 for analysis 1	-,56296	,90447	-2,69296	-,50166	-,30154	,71409	,03394

Table 38: Research Question Testing. Cluster Analysis – Number of Cases in each Cluster

Number of Cases in each Cluster

Cluster	1	4,000
	2	21,000
	3	2,000
	4	19,000
	5	33,000
	6	11,000
	7	8,000
Valid		98,000
Missing		,000

APPENDIX M: SURVEY

Q1 The research is being conducted as part of a Master's thesis project. The study aims to understand preferences towards alternative dairy food products (specifically precision fermentation). The survey will take approximately 4-5 minutes to complete. The responses are anonymous and will only be used for research purposes only. Within this study, your personal preference is highly valued. There are no right or wrong answers. Therefore, please be honest when providing your answers. Thank you for your time! For any further questions regarding the purpose of this research, please get in touch with Lara Lopes (s-laklopes@ucp.pt).

End of Block: Introduction

Start of Block: Screening Questions

Q2 Are you currently living in Germany?

- ○ No (1)
- ○ Yes (2)

End of Block: Screening Questions

Start of Block: Consumer Behavior

Q3 What type of dietary preferences or restrictions do you follow?

- ○ Flexitarian (1)
- ○ Omnivore (I eat everything) (2)
- ○ Vegetarian (3)
- ○ Vegan (4)
- ○ Pescatarian (5)
- ○ Other (6)

End of Block: Consumer Behavior

Start of Block: Precision fermentation

Q4 Have you ever heard of precision fermentation in the context of food?

- ○ No (1)
- ○ Yes (2)

Q5 How familiar are you with precision fermentation as a food technology?

- ○ Not familiar at all (1)
- ○ Slightly familiar (2)
- ○ Moderately familiar (3)
- ○ Very familiar (4)
- ○ Extremely familiar (5)

End of Block: Precision fermentation

Start of Block: Perception towards PF

QX Here is a quick information on Precision fermentation in the context of food: Precision fermentation involves changing the DNA of organisms, which opens opportunities to produce bioidentical milk proteins without any cows or other dairy animals. This allows the creation of almost any type of cheese, free of antibiotics, lactose, and hormones.

Q6 How important are the following factors in motivating you to try precision fermentation cheese?

	Not at all important (1)	Slightly important (2)	Moderately important (3)	Very important (4)	Extremely important (5)
Taste (1)	○	○	○	○	○
Texture (2)	○	○	○	○	○
Ethical considerations (e.g. animal welfare) (3)	○	○	○	○	○
Environmental sustainability (4)	○	○	○	○	○
Health benefits (Nutritional value) (5)	○	○	○	○	○
Curiosity about new food technologies (6)	○	○	○	○	○
Packaging (7)	○	○	○	○	○

Q7 What are your primary concerns about precision fermentation cheese?

- ○ Taste (1)
- ○ Texture (2)
- ○ Health (3)
- ○ Safety (4)
- ○ Association with genetic modification (5)
- ○ Price (6)
- ○ Lack of information about the production process (7)
- ○ Other (8) _____

Q8 How likely are you to try precision fermentation cheese if it tastes similar to traditional cheese?

- ○ Extremely unlikely (1)
- ○ Somewhat unlikely (2)
- ○ Neither likely nor unlikely (3)
- ○ Somewhat likely (4)
- ○ Extremely likely (5)

Page Break

Q9 How much do you agree with the following statement: “I would trust precision fermentation cheese if it was clearly labeled with transparent production information”?

- ○ Strogly disagree (1)
- ○ disagree (2)
- ○ Neither agree nor disagree (3)
- ○ Agree (4)
- ○ Strongly agree (5)

Q10 What type of information would make you feel more confident about purchasing precision fermentation cheese? (Select all that apply)

- ○ Details on environmental impact (1)
- ○ Details on health (2)
- ○ Explanation of the production process (3)
- ○ Certification from trusted organizations (4)
- ○ Consumer reviews and testimonials (5)
- ○ None of the above (6)

Q28 To make sure you are paying attention, please select "Strongly disagree" for this statement.

- ○ Strongly disagree (1)
- ○ Somewhat disagree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat agree (4)
- ○ Strongly agree (5)

End of Block: Perception towards PF

Start of Block: Block 6

Q11 How likely are you to purchase precision fermentation cheese if it costs slightly more than traditional cheese?

- Extremely unlikely (1)
- Somewhat unlikely (2)
- Neither likely nor unlikely (3)
- Somewhat likely (4)
- Extremely likely (5)

Q12 How much would you be willing to pay for precision fermentation cheese compared to traditional cheese?

- Less than traditional cheese (1)
- The same as traditional cheese (2)
- Up to 10% more than traditional cheese (3)
- Up to 25% more than traditional cheese (4)
- More than 25% more than traditional cheese (5)

Q13 How likely are you to recommend precision fermentation cheese to others if you found it satisfactory in taste and texture?

- Extremely unlikely (1)
- Somewhat unlikely (2)
- Neither likely nor unlikely (3)
- Somewhat likely (4)
- Extremely likely (5)

Q14 How often do you think you would consume precision fermentation cheese if it met your expectations?

- ○ Daily (1)
- ○ 2-3 times a week (2)
- ○ once a week (3)
- ○ once or twice a month (4)
- ○ Rarely (5)
- ○ Never (6)

End of Block: Block 6

Start of Block: Demographics

Q15 Please specify your gender.

- ○ Male (1)
- ○ Female (2)
- ○ Non-binary / third gender (3)
- ○ Prefer not to say (4)

Q16 Please select your approximate annual household gross income per year.

- ○ Below ¬20,000 (1)
- ○ ¬20,001 - ¬40,000 (2)
- ○ ¬40,001 - ¬60,000 (3)
- ○ ¬60,000 - ¬80,000 (4)
- ○ Above ¬80,000 (5)
- ○ Prefer not to respond (6)

Q17 What is your current occupational situation?

- ○ Employed (1)
- ○ Self-employed (2)
- ○ Apprenticeship (3)
- ○ Studying (4)
- ○ Other (5)
- ○ Prefer not to say (6)

Q18 What is your age?

_____

End of Block: Demographics