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MOO-VING TOWARDS THE FUTURE

How to foster consumer acceptance of precision fermentation technology & animal-free dairy proteins?

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AARHUS UNIVERSITY

MAPP CENTRE – RESEARCH ON VALUE CREATION IN THE FOOD SECTOR
DEPARTMENT OF MANAGEMENT
AARHUS UNIVERSITY

MOO-VING TOWARDS THE FUTURE:

How to foster consumer acceptance of precision fermentation technology & animal-free dairy proteins?

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Foreword

This research report is part of the Consumer Acceptance of Precision Fermentation Products project and has been prepared by the MAPP Centre, Department of Management, Aarhus BSS, Aarhus University for Food & Bio Cluster Denmark. In this report the results of an experimental study on consumer acceptance of precision fermentation technology and animal-free dairy products are presented. Key findings are of interest for both the industry and public institutions. The report is based on a review of the consumer research literature, the current state of the market, including current legislation, as well as experimental research carried out at the MAPP Centre during the final quarter of 2023.

We invite you to explore our findings from the report: Moo-Ving towards the Future: How to foster consumer acceptance of precision fermentation technology and animal-free dairy proteins?

Best from the authors,

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Internal revision

The internal revision of the report has been undertaken by Klaus G. Grunert. Klaus G. Grunert is Professor of Marketing at Aarhus University, and is the founder of the 'MAPP Centre – Research on Value Creation in the Food sector' at the Department of Management, Aarhus School of Business and Social Sciences, Aarhus University. He is a consumer behaviour researcher with an interdisciplinary orientation. Most of his research is on consumer behavour with regard to food and drink with a background in the disciplines of marketing, agricultural economics and food science. He has dealt with questions on the relationships of consumer decision-making, consumer values and attitudes, consumer experience and consumer lifestyle.

Thank you, Klaus!

Acknowledgments

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Key findings

- Low Purchase Intent and Price Sensitivity: Danish consumers exhibit a low willingness to buy and pay for animal-free dairy products, suggesting the need for more attractive pricing and persuasive marketing strategies.
- Prevalence of Negative Perceptions: Precision fermentation is frequently associated with negative terms such as 'artificial' and 'deceptive', leading to consumer skepticism and fear.
- Positive Associations Exist: Despite negative views, precision fermentation is also perceived positively as 'smart', 'innovative', and 'future-oriented', with potential environmental and health benefits.
- Representative Heuristics in Communication Effective: Communications employing representative heuristics, by drawing parallels to traditional fermentation, show effectiveness in improving consumer familiarity and acceptance.
- Preference for Hybrid Products: A notable preference exists for hybrid products that blend conventional and animal-free dairy proteins, especially in indulgent and functional categories.
- Varied Interest Among Consumer Segments: Interest levels in animal-free dairy products vary among different consumer segments, with particular appeal to pescatarians, vegans, and millennials. Higher purchase intent for animal-free dairy products is also observed in specific regions, notably the Capital Region of Denmark.

Section 1: Introduction

From Microbes to Consumers: The Potential of Precision Fermentation

Demand for animal-based proteins will double until 2050

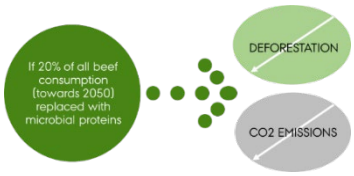
The demand for meat is expected to almost double by 2050 (FAO et al., 2022). However, the current methods of meat production are inadequate for meeting this demand if the global goals related to climate, food security, and public health are to be achieved (Banovic, Barone, et al., 2022).

Alternative proteins are a scalable solution

Shifting towards alternative protein sources offers a promising solution to efficiently and safely feed a growing population (Banovic, Arvola, et al., 2022; Onwezen et al., 2021), and it is as crucial for mitigating climate change as the global transition to renewable energy (Pais et al., 2020). In comparison to traditional meat production, alternative protein production, such as plant-based or marine-based, significantly reduces greenhouse gas emissions, uses less land, and can provide sustenance to more people while conserving scarce resources (Yip et al., 2013). Alternative proteins thus present a scalable solution that, with support from both the public and private sectors, have the potential to address some of the most significant challenges of the global food system and allow for its transformation (Avelar et al., 2022) .

Microbial proteins from precision fermentation can enable shift towards a more sustainable, secure, and just future

One particularly potent, novel technology for responding to these challenges is the utilization of microbial or precision fermentation technology to produce animal-free substitutes for traditional animal-based proteins (Banovic & Grunert, 2023). When implemented at scale, these alternative proteins generated through precision fermentation technology have the capacity to facilitate transformation to the less resource-intensive methods than those currently employed in food production (Teng et al., 2021).



In a simulated scenario, in which 20 percent of all beef consumption (by 2050) was replaced with microbial protein, it was demonstrated that such a change could potentially cut deforestation and related CO_2 emissions from the food system in half (Humpenöder et al., 2022). As nations have pledged to reduce emissions by half and safeguard 30 percent of the world's land and ocean ecosystems by 2030 (FAO, 2023), there is an urgent need to prioritize research and investments in innovative technological approaches, such as precision fermentation, to produce animal-free meat and dairy, and allow for a transformation of the food system towards a more sustainable future.

In contrast to plant-based proteins, microbial proteins can enable production of food that resonate with consumers having the same nutritional profile as animal-based proteins

By using precision fermentation to redesign animal-based protein, there is a potential to construct a future that is more sustainable and secure (Durkin et al., 2022; Van Peteghem et al., 2022), but also to create food that resonates with current consumers' demand for food possessing better nutritional profile (Banovic & Grunert, 2023). In fact, microbial proteins can produce animal-free products that are nutritionally equivalent to their animal-derived counterparts, and thus superior to plant-based products, meaning that consumers can enjoy products without relying on the exploitation of animals (Mouat et al, 2018). This may potentially lead to a reduction in demand for animal products.

The current report describes the main potentials of fermentation-based alternative proteins that could foster their adoption in the food market. There are still obstacles to overcome. In addition to consumer scepticism, these obstacles include governmental regulations pertaining to precision fermentation technology and its products, which need to be addressed to fully unlock the potential of this technology. This challenge persists, although the Food Fermentation Europe (FFE) alliance has worked for new regulations in relation to precision fermentation technology and has been calling for a non-discriminatory, market-based regulatory framework to facilitate more sustainable food systems in Europe.

Section 2: Commercial landscape

State of the market

Precision fermentation products can substitute traditional animal-based products

The traditional practice of fermentation has recently experienced a resurrection, largely attributed to advancements in precision fermentation technology (Tubb & Seba, 2021). Precision fermentation uses microbes as specialized 'cell factories' to produce specific ingredients, ranging from enzymes and natural pigments to proteins and fats (Teng et al., 2021). Notably, these ingredients have the capacity not only to substitute traditional animal-based products, such as meat and dairy, but also to enhance sensory and functional attributes in food formulations, as well as reduce negative externalities related to the food system (Capozzi et al., 2021).

Urgent push needed for regulatory frameworks

However, a significant challenge in introducing this innovative technology to the European market lies in the existing regulatory processes, which have been characterized as excessively long and unclear (Augustin et al., 2023). An urgent push to the regulatory frameworks has been deemed necessary to streamline market access of precision fermentation technology (FFE, 2023). In response to these challenges, stakeholders in the precision fermentation sector have collaboratively established an organization known as Food Fermentation Europe (FFE) alliance. FFE alliance is committed to advocating for a forward-looking regulatory environment that can facilitate the introduction of more sustainable, animal-free food products and ingredients into the European market (FFE, 2023).

European market

No precision fermentation products on European

Currently there are no food products on the European market using precision fermentation technology. In the EU, companies are facing a regulatory challenge over permission to use microbial proteins, in part because it relies on genetic modification. Things are moving faster in the U.S. In 2019, the U.S. Food and Drug Administration (FDA) approved a Perfect Day's animal-free dairy protein (beta-

market

lactoglobulin), a product derived from milk proteins, and documented it as being Generally Recognized as Safe (GRAS) (FDA, 2019). Since then food products such as milk, ice-cream, and cheese are being tested in selected food stores (Crawford, 2023).

Food Fermentation Europe (FFE)

Several startups – Better Dairy, Formo, Onego bio, Those Vegan Cowboys, Imagindairy, Standing Ovation, and Vivici – decided to form a new trade alliance to address the challenges they are facing in securing regulatory approval in the EU. FFE is a trade association that intends to assist new precision fermentation start-ups in navigating the regulatory pathway for approving novel foods in the EU, a lengthy procedure that they consider unclear (FFE, 2023). FFE contends that the European Food Safety Authority (EFSA) has not precisely stated what information is required to secure approval under the EU Novel Foods Regulation. Subsequently, FFE has requested more transparency and improved communication from EFSA to be able to prepare a strong dossier.

Novel food regulations still not in place for precision fermentation products in the European market

In order to be placed on the EU market, novel foods – such as products made using precision fermentation technology – must secure approval under the EU Novel Foods Regulations (EFSA, 2023). The EU Novel Foods Regulation lays down rules for the introduction of novel foods into the European Union market. These provisions aim to ensure the effectiveness of the internal market while simultaneously protecting consumer and human health concerns. The new products also have to be properly labelled to avoid misleading consumers. As a general principle, novel foods must be safe, and the precautionary principle will be used if their safety cannot be determined and if continued scientific uncertainty persists.

The European Institute of Innovation and Technology (EIT), is taking concrete actions to transform food systems, in accordance with the EU's main policy goals, such as the Green Transition. In a 2022 report, EIT Food stated that protein diversification can play an important role in the reduction of our environmental impact (EIT, 2022b). Even if activity in precision fermentation has been slow, in part due to regulatory challenges, they claim innovation is still occurring in these areas.

The Anatomy of Precision Fermentation

Traditional fermentation paves the way for precision fermentation applications

Traditional fermentation technology has been employed for millennia to create a diverse range of food products and drinks, such as bread and beer. Nevertheless, there is a still tremendous unexploited potential and endless opportunities for new applications through use of precision fermentation technology - from fermentation-derived ingredients - to novel protein sources (Teng et al., 2021). Precision fermentation technology involves using microbial fermentation that can produce a wide range of products, including food, pharmaceuticals, and materials, with greater precision and efficiency than traditional methods (Augustin et al., 2023). Specifically, this technology uses genetically engineered microbes that are optimized to produce specific compounds or proteins, and the fermentation process can be controlled and monitored with advanced software and sensors (Boukid et al., 2023). When compared to product synthesised naturally by traditional fermentation and via precision fermentation technology, except that the later achieves superior yield and purity (Teng et al., 2021).

Precision fermentation can enhance sensory and functional properties of food in general, as well as of plant-based products and hybrid alternatives with fewer resources and a smaller environmental footprint

Fermentation techniques have generally demonstrated their capacity to enhance the sensory, functional, and nutritional attributes of numerous alternative protein ingredients (Capozzi et al., 2021; Teng et al., 2021). The prevalence of fermentation practices is particularly prominent in industries like cheese production (rennet). It also holds the potential to yield various products, encompassing egg proteins, dairy proteins and animal-free meat proteins, including fats (Augustin et al., 2023). Notably, proteins such as myoglobin contribute significantly to the characteristic taste and aroma of meat, and the integration of these proteins into plant-based products enables companies to create offerings that closely emulate their conventional counterparts (Teng et al., 2021). Besides possibility to produce high-quality products with the fewer resources and a smaller environmental footprint, precision fermentation has a potential to support the shift towards new carbon–neutral food system (Humpenöder et al., 2022; Van Peteghem et al., 2022).

Animal-free product launches on the market

US market of animal-free products flourishing

While there are no food products in the European market based on precision fermentation technology, the animal-free product launches in the US are flourishing. In the US market, three companies have GRAS status, namely Remilk (Israel), Imagine dairy (Israel) and, Perfect Day (US). With their help, prominent dairy products such as milk, cheese, and ice cream have undergone transformation, utilizing dairy-identical animal-free proteins. Subsequently, a growing cohort of precision fermentation developers has emerged to address the growing demand for more sustainable alternatives to traditional dairy products. In 2022, 842 trillion US dollars have been invested in precision fermentation-derived proteins (GFI, 2022). In the same year, 2022, a multitude of products have been launched on the market as presented in Figure 1.

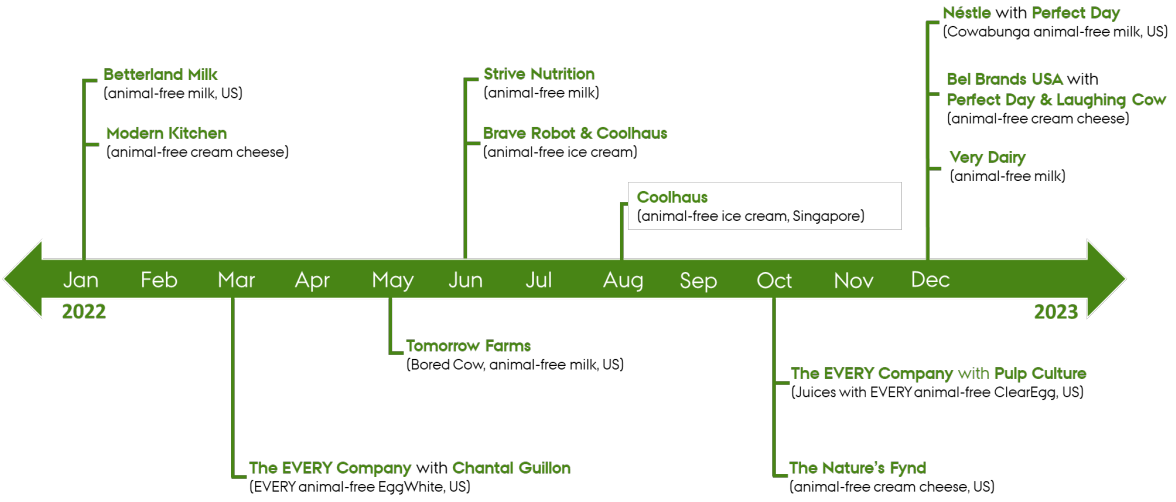


Figure 1. Precision fermentation animal-free product launches in 2022 and respective companies, adapted from GFI (2022).

Companies and products

General Mills was the first major food company to take the leap in innovating with precision fermentation ingredients. G-Works is General Mills' corporate venture studio, which was created to address food-related consumer concerns through experimental innovation. In 2021, they launched the start-up Bold Cultr, which produced animal-free cream cheese that uses whey from the Perfect Day company. Later on, they switched supplier and used whey ingredients from the Israeli company Remilk. The cream cheese was available in several stores in the state of Minnesota, but in February 2023 General Mills decided to discontinue Bold Cultr (Watson, 2023b).

Perfect Day teamed up with Nestlé in 2022 and developed *Cowabunga*, which offers two types of animal-free milk, regular and chocolate. These are currently being trialed in six stores in California. The same year *Perfect Day* also collaborated with *Tomorrow Farms* launching its *Bored Cow* line of flavoured milk drinks. Perfect Day is also collaborating with Mars to develop an animal-free dairy chocolate bar, Co2coa. Initial feedback from consumers indicated a confusion between the animal-free label and the sustainability message. Speaking at the Fermentation-Enabled Alternative Proteins event in San Francisco, Mars' plant sciences director Carl Jones said Mars was still in 'test-and-learn mode' with animal-free dairy (Watson, 2023b).

The Urgent Company is the consumer-facing subsidiary of *Perfect Day*, and it was set up in 2020. One of their main points of focus is the ice-cream brand *Brave Robot*. The company also acquired in 2021 the regular ice-cream brand Coolhaus, which they hope to help transition to animal-free dairy.

Remilk intend to build the world's largest precision fermentation facility in Denmark. The facility they are currently constructing can expand very significantly, is more cost-effective and can be further scaled up (Watson, 2023a).

Section 3: Public interest

Rising of the public interest

Precision fermentation technology has gained a lot of public attention in recent years as a promising solution for producing food ingredients in general, including animal-free dairy products, which are molecularly identical to their animal-derived counterparts (Teng et al., 2021). Interest in this technology is not limited to industry specialists: the public is progressively realizing that there are more ways to mitigate climate change, and alternative products need to be produced. A survey conducted in France, Germany, Italy, and Spain showed that more than 60% of consumers would like to see more alternatives to conventional animal products (GFI, 2022).

An EIT Food project (EIT, 2022a) and several surveys conducted in three European countries (i.e., Denmark, Germany and Poland) (see Banovic & Grunert, 2023; Banovic & Grunert, 2024), was featured in the 2023 BBC Podcast The Inquiry (BBC, 2023). These investigations showed the importance of framing effects and presented information on acceptance of the precision fermentation products, which can help override belief of the possible 'artificiality' of these products. The skepticism around artificiality comes mainly from the fact that the microbes used in precision fermentation are genetically modified, however the produced ingredients are not. The confusion around this information could lead consumers to be discouraged by the mere association with genetically modified organisms, and this is why details about this technology must be efficiently communicated.

Consumer acceptance contingent on perceived naturalness and familiarity

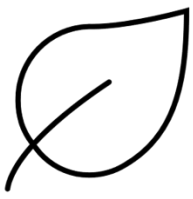
In examining the determinants that shape consumers' acceptance of precision fermentation technology and its associated products, research by Banovic and Grunert (2023) revealed that describing precision fermentation as 'natural' as opposed to 'sustainable' markedly bolstered consumer acceptance. Additionally, they observed that aligning precision fermentation with conventional technology led to heightened levels of trust and perceived benefits, factors that play a pivotal role in influencing acceptance and purchasing intentions. Thus, they concluded that effective

communication and strategic framing are paramount in enhancing the market reception of precision fermentation products.

Fear, skepticism, and distrust inhibit acceptance

In contrast, the fact that the origin of precision fermentation is not a 'food source' (as the protein is synthetized by microbes) may generate fear, skepticism and distrust, and even perhaps disgust (Banovic & Grunert, 2024). Moreover, the technology may be associated with artificiality – due to the integration of genetic material into microbes – thus representing another constraint to product acceptance. Specifically, products framed as "high-tech" have the least positive attitudes among consumers (Bryant & Dillard, 2019). In fact, it has been found that skepticism, fear and food neophobia can inhibit consumer acceptance of precision fermentation technology and consequently of the related products (Banovic & Grunert, 2023). In terms of perceived risks, insights from the current literature on novel technologies, such as GMO, suggest that opportunities for precision fermentation rely on its appeal to healthiness, tastiness, naturalness, sustainable production, being GMO- free and non-associated with allergies. These attributes are important for the acceptance of alternative proteins and protein-enriched products (Banovic et al., 2018; Onwezen et al., 2020).

Precision fermentation sustainability and its pitfalls need to be delt through LCA



Sustainable

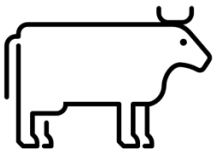
Yet, precision fermentation is considered eco-friendly and sustainable for several reasons. Firstly, it can reduce the environmental impact of traditional agriculture, a significant contributor to greenhouse gas emissions, land use, and water pollution (Balafoutis et al., 2017). Secondly, it is possible to produce products using significantly fewer resources, such as land, water, and energy, than traditional agriculture (Terefe, 2022).

While precision fermentation technology holds the promise of optimized waste reduction, this is not invariably the case. Research shows that in numerous instances, a mere 5% of the contents of a fermentation container comprises the target product, the rest constituting side-streams (Augustin et al., 2023). This aspect raises significant concerns within the industry. Consequently, when evaluating the sustainability of a product derived through precision fermentation, a comprehensive life cycle analysis (LCA) becomes indispensable (Humpenöder et al., 2022). This analysis should

encompass a thorough examination of various factors, including the input/output ratios, the extent of waste generation, and the consumption of energy and water resources. Such an approach is crucial to ensuring a more balanced and realistic perspective of the technology's sustainability.

Healthy

Precision fermentation technology has the potential to produce healthier products due to its ability to optimize the production of specific compounds, such as vitamins, minerals, and other bioactive molecules, that are essential for human health (Teng et al., 2021). By precisely controlling the production process, these compounds are produced in a more concentrated and bioavailable form than traditional, agricultural methods. Additionally, precision fermentation can be used to produce functional ingredients, such as probiotics and prebiotics, that have been shown to improve gut health and overall well-being (Dimidi et al., 2019). This advanced control over the production process also allows for the creation of products that are free from harmful contaminants, such as pesticides, antibiotics, and heavy metals, further contributing to the health benefits of precision fermentation products (Zollman Thomas & Bryant, 2021).



Animal-friendly

A study by Broad et al. (2022) used focus groups to explore early-adopter perceptions of the precision fermentation process. Participants expressed cautious interest in animal-free dairy products and were most convinced by the claims about animal welfare. In fact, precision fermentation technology was considered better for animal well-being than traditional agriculture. This can significantly reduce the stress and suffering experienced by animals in traditional farming practices. Besides above, other studies have shown that precision fermentation may eliminate the need for animal husbandry, reducing the demand for rising livestock, transport, and slaughter (Santo et al., 2020). By using precision fermentation to produce proteins and other animal products, it is possible to create a more ethical and sustainable food system.

Section 4: Experimental study on consumer acceptance of precision fermentation technology and animal-free dairy proteins

Purpose

The purpose of this research is to determine the degree of consumer acceptance of precision fermentation technology and associated products. Specifically, the main aim is to estimate the degree of acceptance for this innovative technology when applied to produce animal-free dairy proteins, which can subsequently be utilized in the production of animal-free dairy products (Figure 2).

Understanding how to effectively convey information about products from precision fermentation technology is a vital step in addressing the existing health and environmental challenges facing the food industry (Banovic & Grunert, 2023). Here, communication plays a pivotal role in shaping consumer acceptance and influencing their decisions to purchase or consume products containing animal-free dairy proteins.

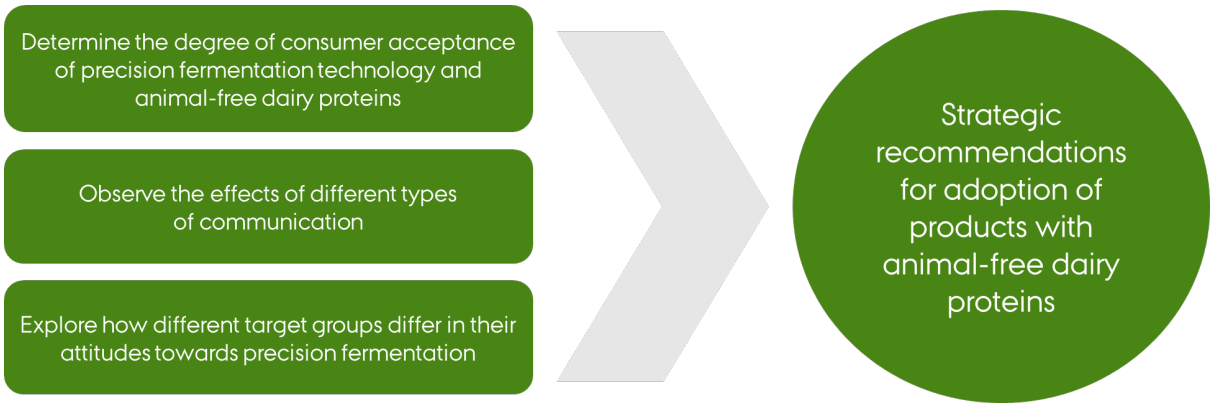


Figure 2. Purpose of the research.

The survey

After informed consent, Danish survey participants were asked about their familiarity with precision fermentation technology, which was followed by a pictorial explanation of how the precision fermentation process works in production of animal-free dairy proteins (Figure 3). This was accompanied by a message explaining the process in simple terms, mainly that precision

fermentation does not involve any animals in production of animal-free dairy protein, but instead uses microbes to produce proteins, same way cow would.

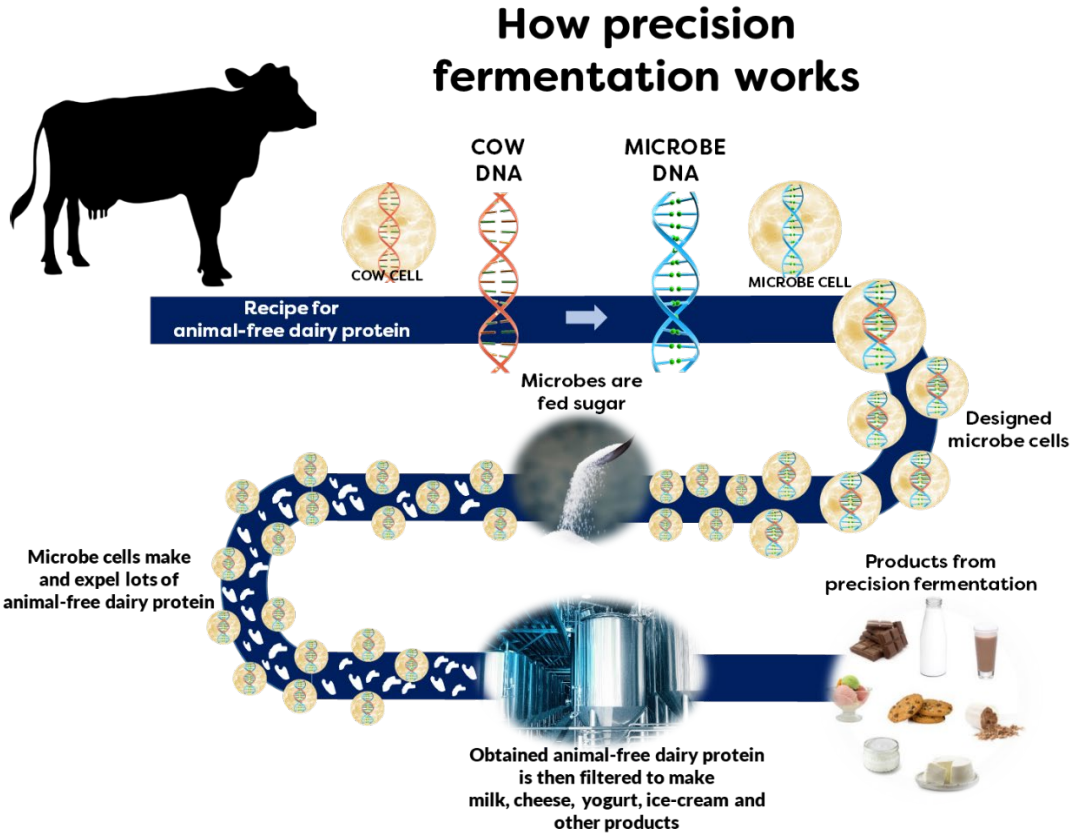


Figure 3. The precision fermentation process iconography, created by the main author.

Research design and message stimuli

Following the explanations above, consumer associations with precision fermentation technology were elicited and subsequently rated for their negative or positive valence. Subsequently, a between-subjects experimental design was applied where participants were randomly assigned to one of four experimental conditions (Figure 4). Three experimental conditions supported use of heuristics: representative heuristics *vs.* affective heuristics *vs.* availability heuristics, and a control condition (where no message was shown) (see example in Figure 5).

Experimental conditions

Representative heuristic	Animal-free dairy products made with precision fermentation were presented as being produced via a traditional method
Affective heuristic	Animal-free dairy products products were presented in an exciting and joyful way
Availability heuristic	Animal-free dairy products products were presented as being popular and already available for purchase
Control	In this condition no message was presented

Figure 4. The experimental conditions.

Figure 5. Example of message used for representative heuristic.

Three food product categories, nine products

Nine food products were selected to assess the differences between three food categories (Figure 6), namely functional (milk, yogurt, and cheese), indulgent (chocolate, ice-cream, and cookies), and protein-enriched food products (protein bar, protein drink, and protein powder).

Figure 6. Product stimuli: nine selected products and the corresponding food categories.

Additional dependent and independent measures

The perceived benefits and risks of precision fermentation technology were measured. This was followed by assessment of overall perceived quality of the precision fermentation products (such as sensory appeal, healthiness, nutrition, and ethical aspects, such as moral satisfaction). Subsequently, the likelihood of buying precision information products as well as the prices participants were willing to pay were elicited. Finally, the assessment of the individual participants' traits (such as health and environmental consciousness, and moral satisfaction) was conducted. The survey finished by assessment of frequency of purchase and consumption of different food products (used as a stimuli), and socio-demographics.

Representative sample of Danish consumers

One thousand two-hundred and fifty-three Danish consumers were recruited for the purpose of the study. The sample was nationally representative in terms of demographic criteria, including age (average age of 44 years), gender (50/50% spread between males and females), and regional distribution (Nordjylland, Midtjylland, Hovedstaden, Syddanmark, and Sjælland). Data were also collected on participants' education, dietary preferences, and shopping habits.

Data analysis

The data collected was analysed using standard methods and statistical techniques (such as t-tests, chi-square tests, ANOVA, regressions, and ANCOVA). Sentiment analysis was specifically employed to assess consumer associations. To understand the experimental conditions on the likelihood of buying precision fermentation products ANCOVA was used. To analyse the acceptance of precision fermentation technology and associated products, standard logistic and linear regressions were applied. Further, differences and similarities among consumer groups were assessed using analysis of variance (ANOVA), t-tests, and cross-tabulations (chi-square tests). The above analyses provided insights into consumer perceptions of precision fermentation and how various factors impact the acceptance of this technology and its products.

Section 5: Results from the study on consumer acceptance of precision fermentation technology and animal-free dairy proteins

Consumer associations to precision fermentation technology

Precision fermentation artificial or just incredibly smart?

Danish consumers' association with precision fermentation technology varied significantly, leaning to the negative associations. The most frequently used words as indicated in the word cloud, are 'artificial,' 'smart,' and 'future' (Figure 7).

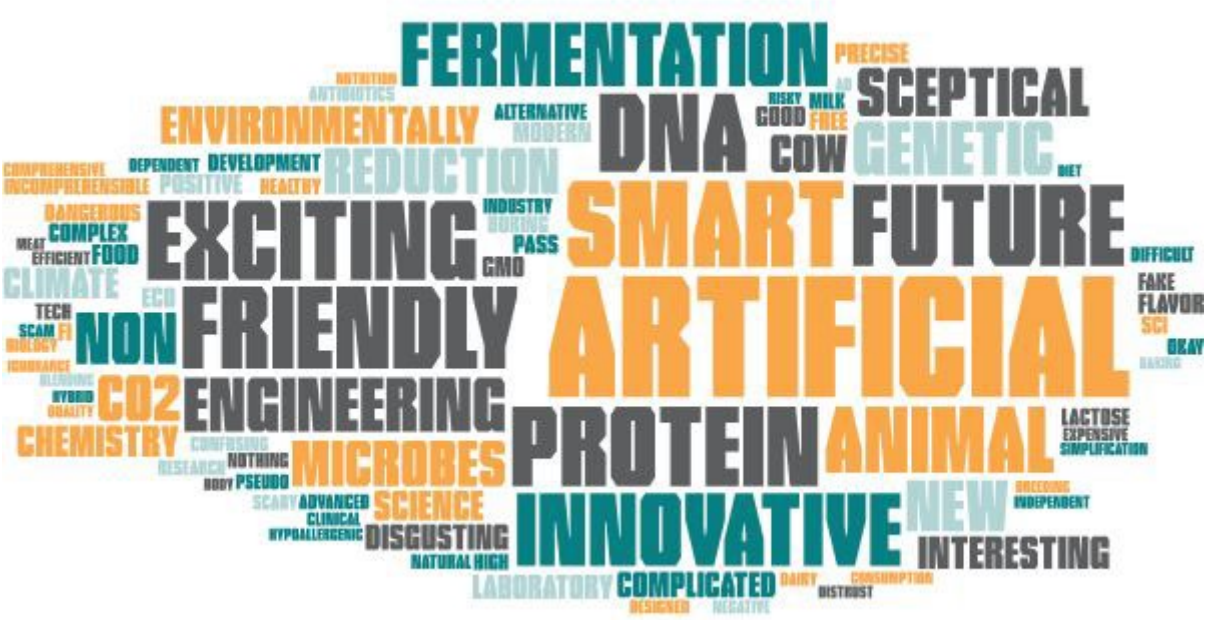


Figure 7. Word cloud represents the most common associations with precision fermentation technology.

Fear and skepticism due to the unfamiliarity

After performing sentiment analysis and examining the valence of the elicited words, negative associations with precision fermentation technology were tilting the scale over positive associations (Figure 8). Precision fermentation was commonly linked with terms like 'artificial,' 'somewhat deceptive,' and 'unnatural,' which triggered subsequent associations related to doubt, skepticism, and fear among Danish consumers. These associations further implied concerns about the technology's transparency in the production process, potentially raising associations to its safety, and ethical implications. Furthermore, the negative associations such as 'artificial' and 'deceptive' were also linked to 'unfamiliarity' suggesting that acceptance of precision fermentation can be met with resistance due to unfamiliarity. This underscores the importance of clear communication to address the above negative inferences and provide consumers with a more comprehensive understanding of the potential benefits of the technology.

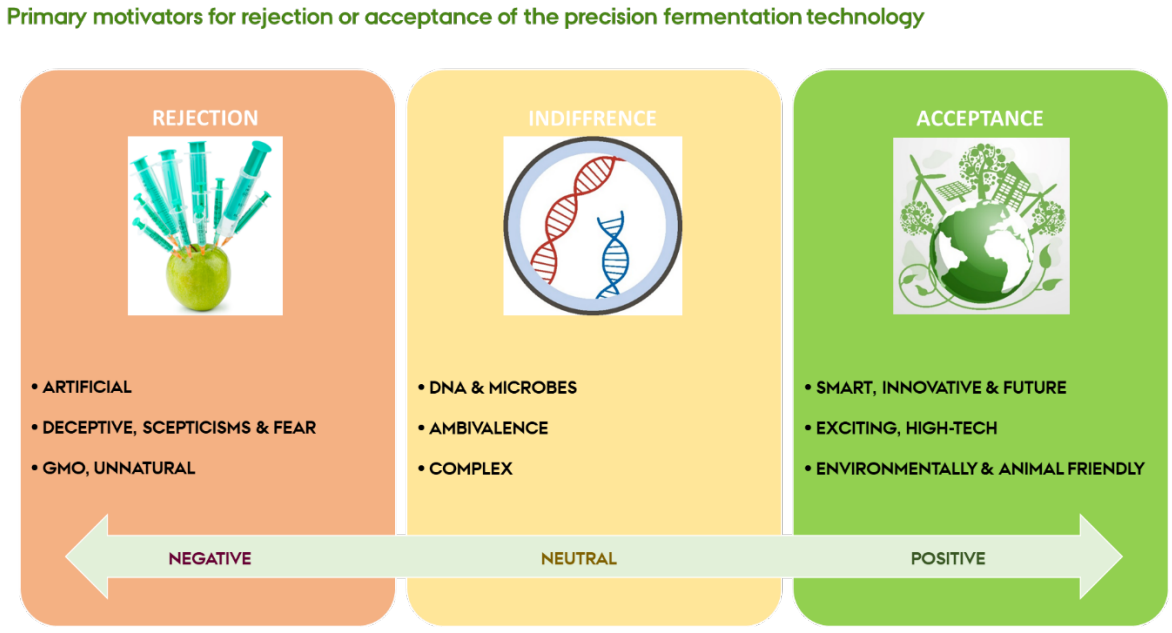


Figure 8. Sentiment analysis of main association in relation to precision fermentation technology.

Precision technology as smart and innovative

Smart and innovative were prominent positive associations, highlighting the resourcefulness of this technology (Figure 8). Danish consumers associated precision fermentation to a technologically advanced and intelligent approach for food production. This suggests a positive association, as 'smart' implied link to

efficiency and intelligence. When further linked with the positive associations for the word 'future,' this indicates that many consumers saw precision fermentation technology as forward-looking and that they believed this technology has the potential to play a significant role in shaping the future of food production. It might also reflect optimism about the potential benefits and advancements that precision fermentation could bring.

Precision fermentation as healthy, environmentally and animal friendly

Additionally, participants often linked precision fermentation with positive environmental aspects and animal well-being, underlining its potential benefits in these areas. Besides, precision fermentation was frequently associated with 'protein', 'health' and 'diet', suggesting that consumers recognize its potential to be a valuable source of protein in the modern diet. This association aligns with the growing interest in alternative protein sources, particularly for those who are seeking sustainable and plant-based options. Further it also suggests that some Danish consumers may view precision fermentation as a technology with the potential to offer health benefits or contribute to a healthier eating pattern.

Effect of communication messages that support use of heuristics on acceptance of precision fermentation technology and animal-free dairy products

What are heuristics and why are they important

Heuristics are cognitive shortcuts that simplify complex decisions, aiding consumers in sifting through ample information (Folkes, 1988; Nagaya & Shimizu, 2023; Pachur et al., 2012; Read & Grushka-Cockayne, 2011; Slovic et al., 2007). Three primary heuristics examined in this study, as previously presented, include availability, affect, and representativeness (see Figure 4 and 5). The availability heuristic sees consumers basing judgments on easily recalled or recently exposed information. The affect heuristic guides decisions through emotions or feelings, often sidelining objective data. The representative heuristic focuses on assessing how closely an event or object mirrors a specific category's typical characteristics. For communicators, recognizing these heuristics is essential. Harnessing these innate mental processes can effectively shape

consumer perceptions and motivate desired behaviours, as in the case of the precision fermentation technology.

Representative heuristic affects consumer attitudes in a positive way

The experimental study showed that the messages that support use of the representative heuristic, when compared to those messages supporting use of availability and affect heuristics, serves as a effective cognitive shortcut, fostering a more positive acceptance of precision fermentation technology (Figure 9). Engagement with this type of communication message thus brings forth several benefits. First, Danish consumers perceive precision fermentation technology as being like traditional fermentation, drawing on familiar patterns rooted in their experiences with traditional fermentation products (e.g., bread and beer). Second, this cognitive simplification proves instrumental in handling complex information related to the precision fermentation technology and, notably, facilitates its understanding. Third, and interestingly, message supporting use of the representative heuristics surpass the effects of those supporting use of the affect and availability heuristics, making it a particularly potent and robust tool for shaping consumer attitudes (Figure 9).

However, it must be noted there is a still long way to go to a full adoption of this technology, as these messages only marginally enhance positive attitudes towards precision fermentation (just above indifference point, see Figure 9).

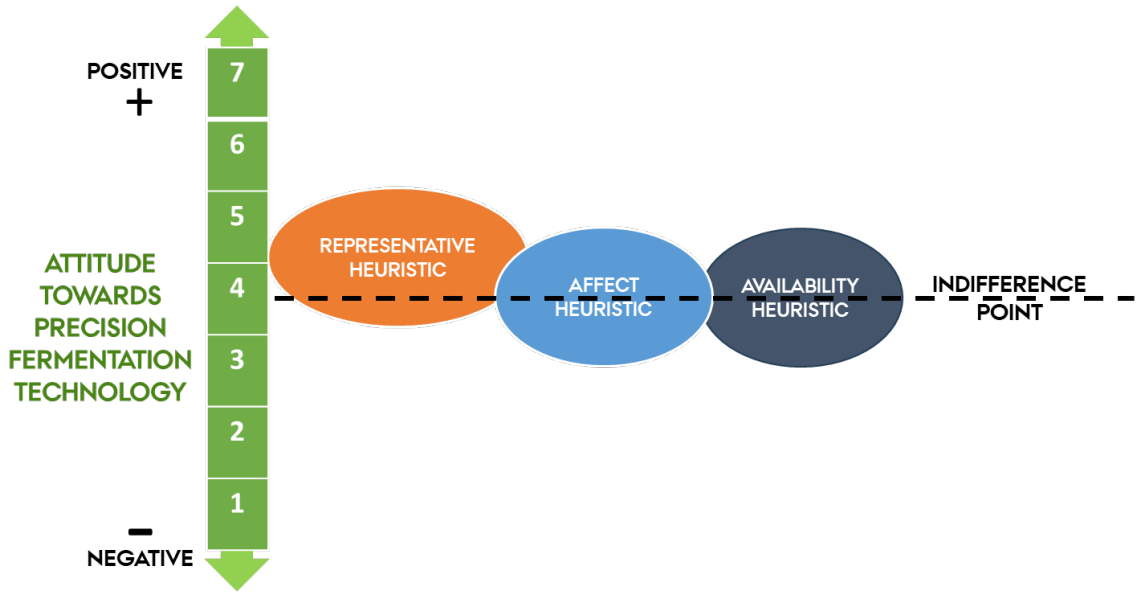


Figure 9. Influence of communication messages supporting use of heuristics on attitudes.

Improving familiarity with technology could increase perceived benefits

Messages supporting use of representative heuristics could also play a role in enhancing the acceptance of technology through amplifying the perceived benefits. In the context of communicating about precision fermentation technology, the messages emphasising on familiarity and linking it with traditional fermentation could bolster positive perceptions by making the technology appear credible, healthy, natural, and environmentally friendly. Thus, the induced perceptions by the messages supporting use of the representative heuristic could possibly contribute to the consumers embracing this novel technology (Figure 10).

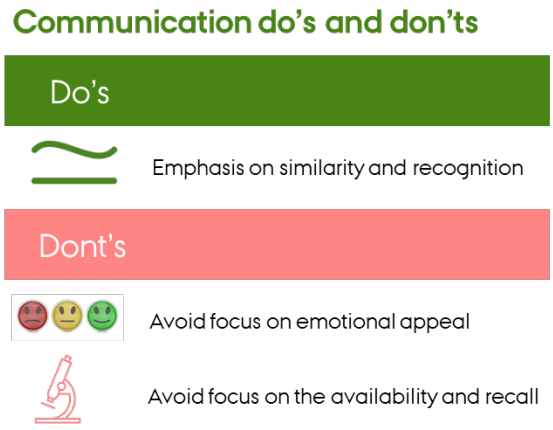


Figure 10. Influence of communication strategies on attitudes towards precision fermentation technology.

Low purchase potential of animal-free dairy products

There is a notable low purchase likelihood for animal free dairy products, with approximately only fair likelihood and 4 in 10 Danish consumers considering the purchase of these products (Figure 11). This likelihood is slightly enhanced when using messages supporting representative heuristics, in contrast to messages supporting use of affect and availability heuristics. Specifically, when the parallels between precision fermentation and traditional fermentation provided, consumers seem to gain somewhat clearer understanding of the production process, positively elevating their inclination to purchase animal-free dairy products.

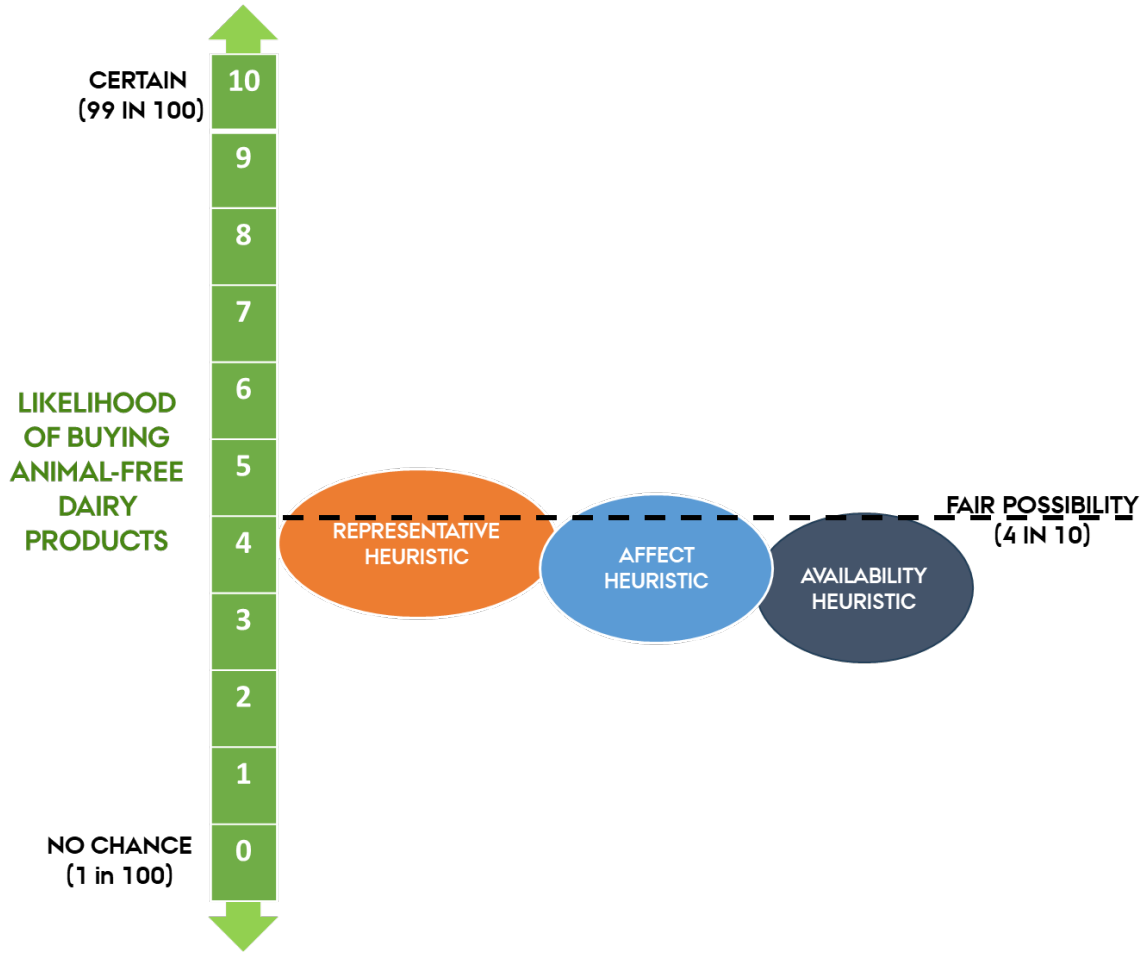


Figure 11. Likelihood of buying animal-free dairy products in general.

Hybrid animal-free dairy alternatives could become competitors to plant-based alternatives

Hybrid products with animal-free proteins could compete with plant-based products

A majority of the Danish consumers still prefer conventional dairy products (41%, Figure 12). Interestingly, hybrid products that contain a blend of proteins from conventional sources and animal-free dairy protein form precision fermentation come as the second choice (18%) followed by products that come 100% from precision fermentation (12%). In fact, Danish consumers prioritize these hybrid products over plant-based products (11%), and hybrid combination of plant-based with animal-free dairy from precision fermentation (11%). It seems that plant-based products will face a fierce competitor in products derived from precision fermentation.

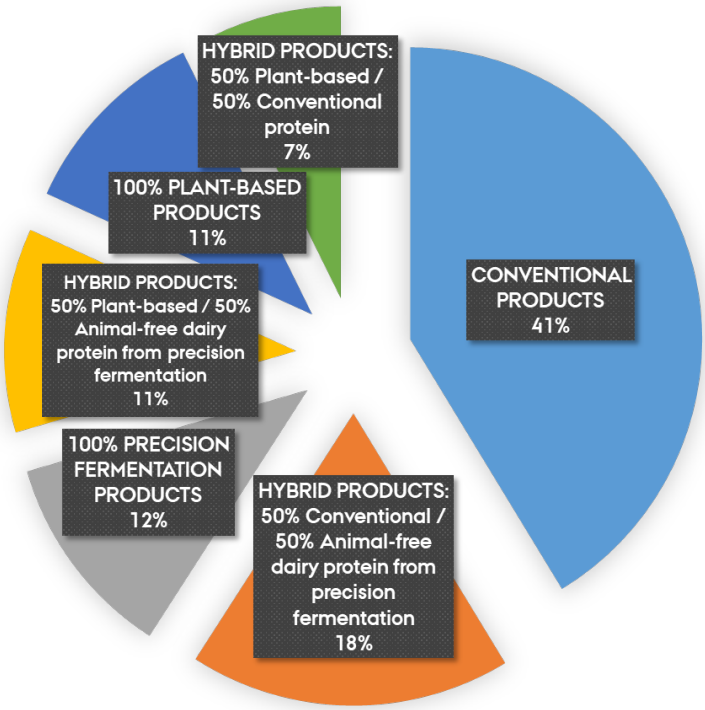


Figure 12. Overall consumers' preference for products coming from different production sources.

Preference for hybrid products in the separate product categories

Similar occurrence, as above, is observed in the separate product categories. While conventional products are preferred, a significant segment of Danish consumers, ranging from 16 to 20 percent across various product categories, demonstrated an inclination towards hybrid offerings consisting of a 50% blend of animal-free dairy from precision fermentation and conventional sources (Figure 13). This is especially evident for indulgent products, namely chocolate (19.2%) and ice-cream (19.1%), followed by functional products, as cheese (20.1%). Products coming from 100% animal-free dairy protein are preferred particularly for protein-based products, namely protein powder (15.2%) and protein drink (14%). This is almost equal to the same category in terms of preference for protein products coming from 100% plant-based protein sources, protein powder (15.6%) and protein drink (14.4%), as well as hybrid products related to the combination of 50% plant-based and 50% animal-free dairy protein sources. These findings hold across all experimental conditions and again point to the fact that plant-based products could face a competitor in precision fermentation products.

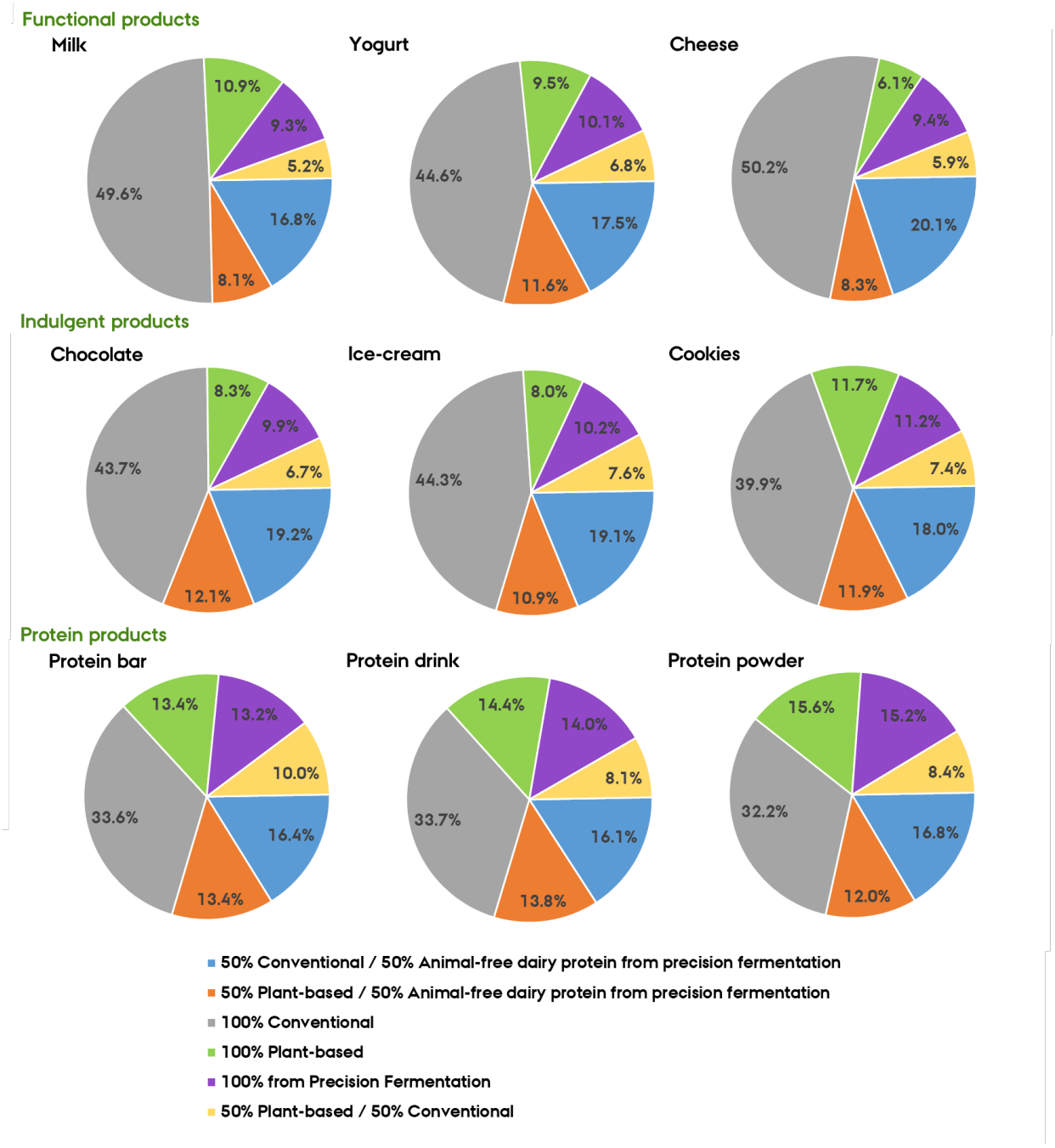


Figure 13. Willingness to buy animal-free dairy products compared to conventional and plant-based products.

Lower willingness to buy and pay for animal-free dairy products

Low likelihood of animal-free dairy products purchase

Examining individual product categories reveals that the overall likelihood of consumer acceptance shifts from a slight possibility to some possibility (Figure 14). Protein-enriched products have very low likelihood of being accepted and bought, followed by functional and indulgent products that only have some possibility of being bought. least accepted. The influence of messages did not have significant affect on separate product categories, as the product category itself becomes a more dominant factor in shaping consumer preferences. This underscores the importance of considering specific product characteristics and consumer preferences within distinct categories when assessing the potential for adoption and acceptance of animal-free dairy products.

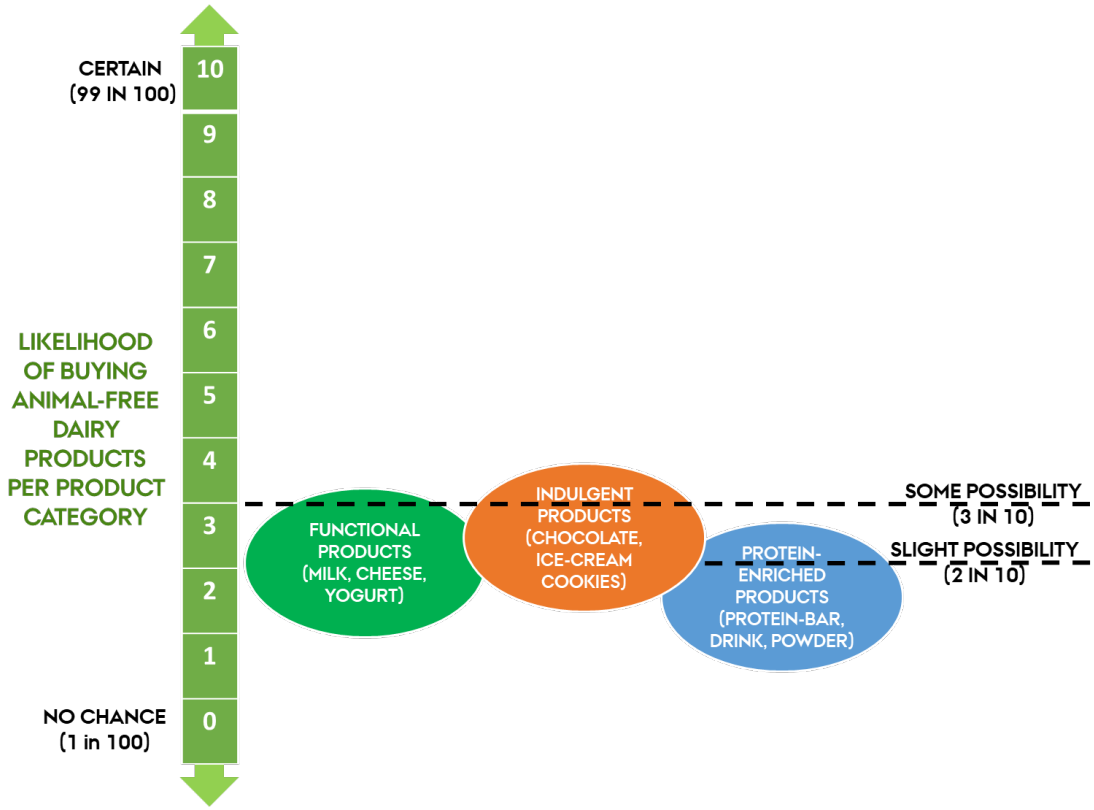


Figure 14. Willingness to buy animal-free dairy products across product categories.

Indulgent products preferred although with low purchase likelihood

When looking into individual product categories, indulgent products such as chocolate and ice-cream hold some possibility of being purchased by consumers. Following closely are functional products like cheese, indicating some possibility of being bought. However, in the case of protein-enriched products such as protein powder, the likelihood of purchase is significantly lower, suggesting a relatively low possibility of consumer acceptance.

Consumers want lower prices for animal-free dairy products when compared to their reference prices of conventional products

In assessing prices of products from different categories, it is evident that consumers generally preferred paying lower prices for animal-free dairy products compared to their reference prices of the conventional counterparts (or prices they usually pay for the similar conventional products) (Figure 15). For example, elicited average reference price of milk is 10.13DKK/l, while price for animal-free diary milk is 9.64 DKK/l. Furthermore, when it comes to indulgent products like ice cream (with elicited reference average price of 18.51 DKK/100ml compared to animal-free dairy ice-cream at 17.94 DKK/100ml). In general, although always preferring lower prices for animal-free dairy products, Danish consumers on average would be willing to pay more for indulgent products than other two product categories of functional and protein-enriched products. Indeed, protein-enriched products, such as protein powder (with a conventional price of 17.43 DKK/100gr compared to animal-free dairy at 16.17 DKK/100gr), despite having higher elicited prices, tend to receive lower rates when compared to the prices elicited by existing products.

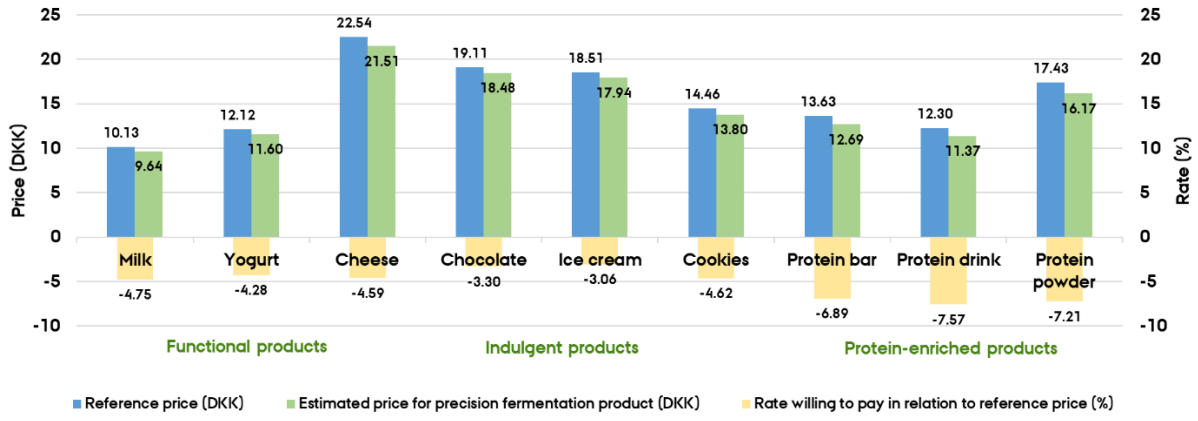


Figure 15. Elicited consumers' prices across product categories., compared to the consumer's reference price.

Importance of sensory appeal and moral satisfaction

Sensory appeal and pleasure aspects are important

Despite the lower levels of purchase intent, Danish consumers want animal-free dairy products that are pleasurable, have a good visual appearance, taste, and texture. In fact, these intrinsic characteristics could possibly increase purchase intent of animal-free dairy products (as shown by the regression analysis). Consumers thus place substantial emphasis on derived pleasure while consuming animal-free dairy products.

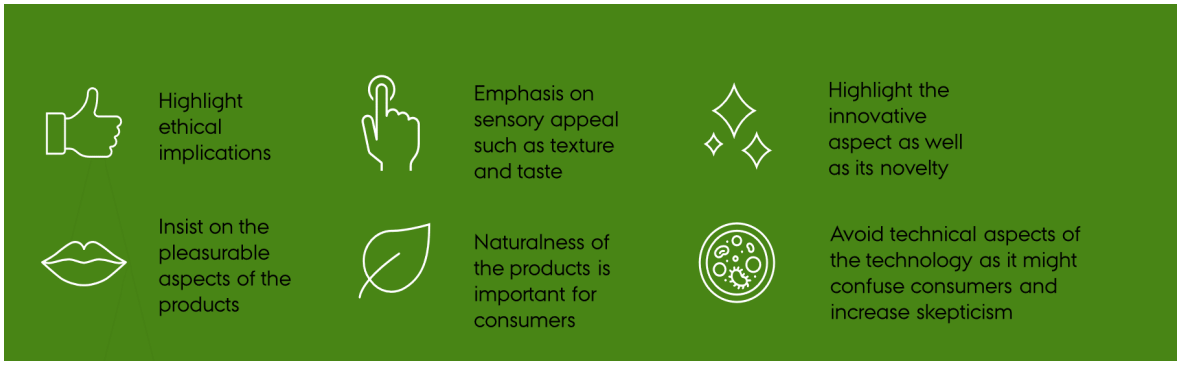


Figure 16. Factors influencing acceptance of animal-free dairy products.

Moral satisfaction and animal-well-being

Among ethical aspects, moral satisfaction was found (in the regression analysis) as the important driving force behind consumers' purchase intent when it comes to animal-free dairy products. It seems that ethical considerations related to animal well-being could play an important role in shaping consumers' preferences for animal-free dairy products. Bringing attention to the ethical aspects of animal-free dairy products could boost consumer interest and prioritization of animal-free dairy products (Figure 16).

Besides the above-mentioned factors, naturalness and similarity to the conventional animal-based products also play a role in consumer preferences for animal-free dairy products. Further, innovations od the technology is well accepted by the consumers, however technical aspects of the technology could confuse the consumer and backfire in the process. Providing a more simplified explanation on the technical aspects of the precision fermentation technology or rather just emphasizing on the benefits of the animal-free dairy product itself is safer root to take.

Consumer segments with higher acceptance levels

Pescatarians, and vegans more interested

Dietary preferences play a significant role in shaping the purchase intent for animal-free dairy products, with distinct patterns emerging among various consumer groups. Most of the consumers, comprising of omnivorous consumers (representing 73% of the cohort), expresses some possibility of considering animal-free dairy products (Figure 17). Pescetarian and vegan consumers demonstrate a good possibility of purchasing animal-free dairy products.

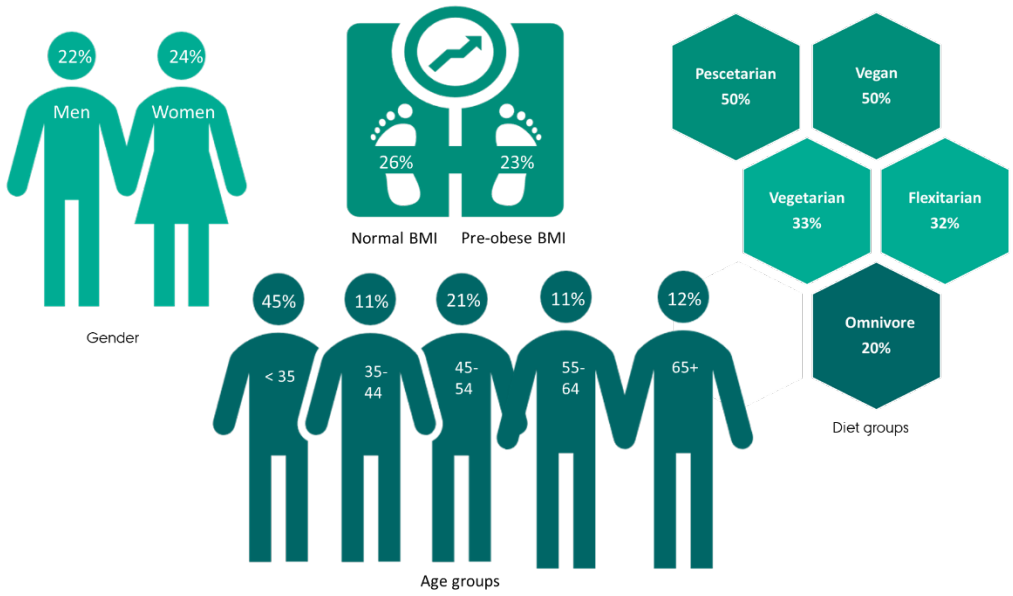


Figure 17. Likelihood of purchasing precision fermentation products across different socio-demographic groups.

Millennials more inclined to buy

Younger consumers, particularly millennials (aged 20-35), are exhibiting a notable disposition toward purchasing animal-free dairy products, signaling a fair likelihood of acceptance when compared to other demographic groups (Figure 17). This trend is indicative of a broader shift among younger generations, who are increasingly prioritizing sustainability and ethical considerations in their food choices.

Males and females exhibit similar interest

Gender-based results indicate no divergence in purchase interest, showing a small proportion of both male and female consumers being interested in

animal-free dairy products. Additionally, all exhibit a similar level of interest when it comes to purchasing of animal-free dairy products (Figure 17).

Capital region of Denmark more interested

Regions differ in their purchasing intent. A larger proportion of people from the Capital Region of Denmark report they are highly likely to buy animal-free dairy products (Figure 18). Second-most interested are people from the Central and Southern regions. The Zealand and North Jutland regions have fewer people who are highly likely to buy animal-free dairy products.

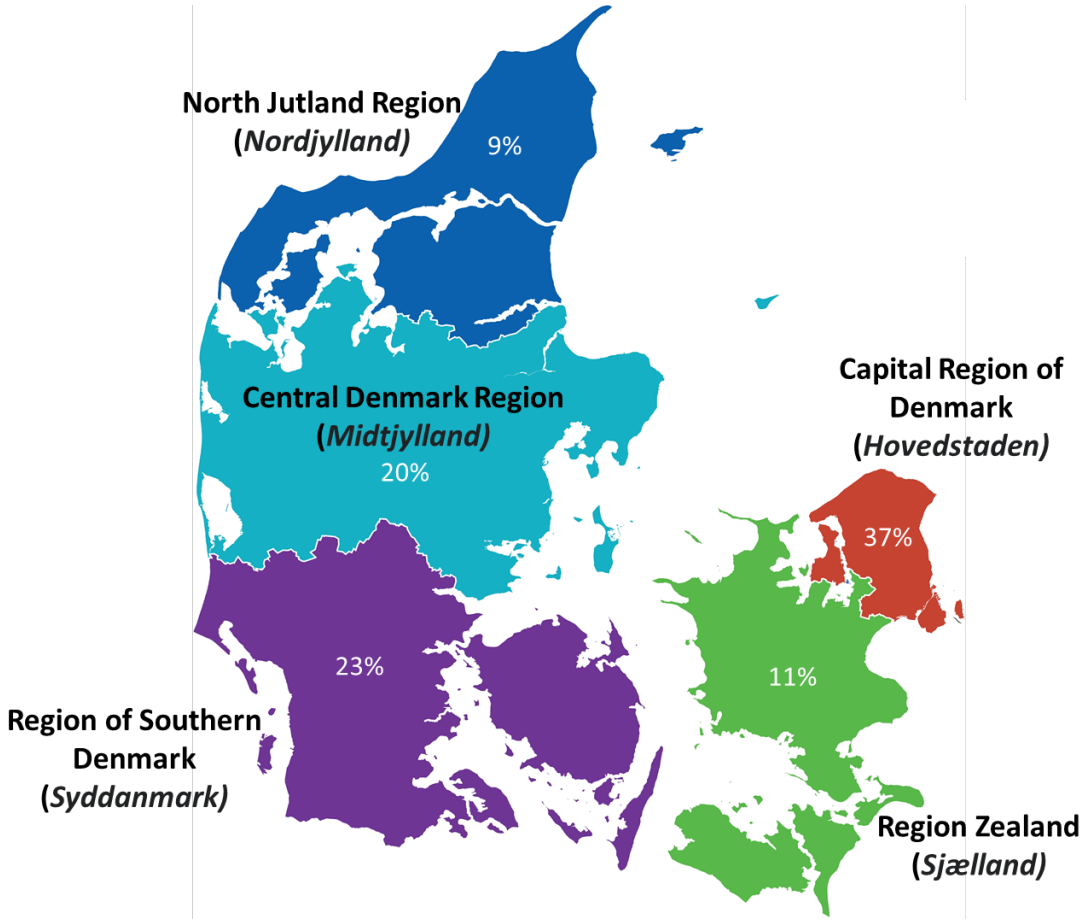


Figure 18. Likelihood of purchasing animal-free dairy products, by regions

Section 6: Strategic recommendations

Based on the findings from the experimental study, here are strategic recommendations for promoting of precision fermentation technology and animal-free dairy products:

- Low Willingness to Buy and Price Sensitivity: Given the lower willingness to buy and pay for animal-free dairy products across product categories, there is a need for strategic pricing and enhanced marketing efforts.
- Address Negative Perceptions: Reduce the negative associations (e.g., 'artificial', 'deceptive') by enhancing transparency about the precision fermentation technology. Educate Danish consumers about the safety and ethical aspects of precision fermentation to mitigate fear and scepticism.
- Leverage Positive Perceptions: Capitalize on the positive perceptions such as 'smart', 'innovative', and 'future-oriented'. Highlight its perceived benefits, and potential role in shaping the future of food production. Emphasize its environmental benefits and potential in providing healthy, protein-rich, and animal-friendly food options.
- Utilize Representative Heuristics in Communication: Use communication strategies that support use of the representative heuristic. Draw parallels between precision fermentation and traditional fermentation to increase familiarity and acceptance. Offer simplified information focusing more on the perceived benefits and its products rather than the complexities of the technology that can confuse consumers. Messages should simplify complex information and link the technology to credible, natural, and environmentally friendly perceptions.
- Focus on Hybrid Animal-Free Dairy Products: Since there is a preference for hybrid products blending conventional and animal-free dairy proteins, especially in indulgent and functional products. By focusing on developing and marketing these products there exists potential for competitive edge over plant-based alternatives.
- Target Specific Consumer Segments: In terms of diet preferences highlight benefits to attract pescatarians and vegans, who show higher interest in animal-free dairy products. Tailor marketing towards millennials who are more inclined to purchase these products, emphasizing on sustainability and ethical aspects. As there is no significant gender-based divergence in interest, ensure marketing campaigns are inclusive and appeal to all genders. Concentrate efforts in regions like the Capital Region of Denmark where higher purchase intent is observed.
- Unique Selling Proposition (USP): Conducting life cycle analyses (LCA) is essential for producers of precision fermentation products to substantiate and reinforce their sustainability claims, as this is a critical USP in today's market.
- Continual Research and Feedback: Regularly assess consumer preferences, as these can evolve. Stay attuned to changes in consumer trends to adapt strategies accordingly.

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Credit Statement

Marija Banovic: Conceptualization, Research Design, Methodology, Investigation, Experimental Work, Data Analysis, Figures and Images Design, Funding Acquisition, Project Administration, Writing, Reviewing and Editing.

Delphine Leardini: Investigation, Data Analysis, Figures and Images Design, Writing.

Alice Grønhøj: Conceptualization, Reviewing, Funding Acquisition.

Jessica Aschemann-Witzel: Conceptualization, Research Design, Reviewing.

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References for Images and Figures

- Title page design done and created by the main author (M. Banovic) using Adobe Spark through Aarhus University's paid subscription.
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- Sections 4 and 5: All figures were created collaboratively by the main author (M. Banovic) and the second co-author (D. Leardini) of this report.

About MAPP Centre

The MAPP Centre is a Research Centre and part of Department of Management at the School of Business and Social Sciences, Aarhus University. MAPP Centre does research on the development, marketing and distribution of foods and the societal impact of the food sector. It further generates insight into customer behaviour in the area of food and drink and analyse the implications of such insight for industry and public policy.

For industry, insight into customer behaviour is a major input in market-oriented product development, which is widely accepted to be a cornerstone in attempts to attain and sustain future competitiveness, and it is also a decisive ingredient in the development and implementation of sustainable business strategies and corresponding competence development.

For public policy, insight into the determinants of food choice and consumption habits is an important basis for the development of policies that address public concerns in the areas of food choice, health and nutrition, and sustainability.