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Master's Thesis

Mycoprotein and New Sources of Protein

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In conclusion, this thesis stands as a testament to the collaborative efforts of a multitude of individuals and institutions. I am humbled by the opportunity to contribute to the field of Mycoprotein research, and I hope that this work serves as a valuable contribution to our understanding of sustainable protein alternatives.

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Abbreviations

Acronym	Abbreviation
TAM	Total Addressable Market
USP	Unique Selling Proposition
PESTEL	Political, Economic, Sociological, Technological, Environmental and Legal
SWOT	Strength, Weakness, Opportunity, Threat
SAM	Serviceable Addressable Market
SOM	Serviceable Obtainable Market
ROI	Return of Investment
EIA	Environmental Impact Assessment

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Abstract

This research paper investigates the potential of Mycoprotein as a sustainable alternative protein source, comparing it to emerging alternatives such as insects and lab-grown meats. *Fusarium venenatum* is a reliable and effective fungus used as the cornerstone for producing Mycoprotein. This study assesses the viability of establishing a Mycoprotein production facility in Norway, focusing on regulatory obstacles, resource needs, and environmental implications. The market analysis encompasses the identification of diverse market segments and the development of a business plan for a B2C Mycoprotein factory.

Mycoprotein possesses several notable strengths, such as its sustainability, high nutritional value, increasing consumer acceptance, and continuous technological advancements. The weaknesses of the business include limited product variety and production complexity. Opportunities arise from the increasing global demand for sustainable proteins, the presence of health-conscious consumers, and the need to diversify product offerings. Threats encompass competition, supply chain disruptions, consumer skepticism, and potential environmental critiques.

This study expands the comprehension of Mycoprotein's potential as a future alternative protein source and provides valuable insights for stakeholders contemplating its production in Norway.

1. Introduction

1.1 Background

According to United Nations (UN), the number of people on earth increased by 1 billion since 2010 and 2 billion since 1998, reaching 8.0 billion by mid-November 2022, up from an estimated 2.5 billion in 1950. Over the next 30 years, the world's population is expected to grow by about 2 billion, from 8 billion to 9.7 billion in 2050, with a potential peak of 10.4 billion (Durán-Sandoval et al., 2023). Science has modernized our lives by increasing life expectancy as well as enhancing the quality of life. But according to the Food and Agricultural Organization (FAO), 1 out of 9 people remains undernourished on the planet (FAO et al., 2015). It's an irony of fate that food security is still one of the biggest challenges on earth, especially the protein supply. Of course, the overall food production has increased by a huge margin to support the demand but extensive dependency on livestock rearing, traditional farming & over-fishing has disrupted the balance of mother nature. Now it's time for a sustainable solution for the food supply chain, otherwise, we will be in great danger within a very short period of time. According to Kutty, we need to alter our long-term perspectives dramatically in order to provide enough food for the world's growing population (Kutty, n.d.).

In order to solve this problem, numerous kinds of new alternative protein sources have been explored. Vegan proteins, Mycoproteins, Insect proteins and Lab meats are considered as alternative protein sources which have the potential to overcome the global hunger through achieving sustainability. Among them, Mycoprotein can be a pretty sustainable and affordable alternative protein source and it has a promising future in fighting against global hunger and malnutrition.

Mycoprotein is a type of fungal protein that can be used as an alternative source of protein for both human consumption and animal feed (E. J. Derbyshire & Delange, 2021). The potential of mycoprotein as an alternative protein source is limitless, and its impact on food security and nutrition is still under research (Wiebe, 2002). Furthermore, it is also needed to discuss the challenges associated with its production and consumption, and the potential solutions to these challenges; so that customer acceptance of Mycoprotein as an alternative protein source (in the form of food and feed) increases.

1.2 Circular economy and New sources of Protein

In recent years, the idea of a circular economy has been attracting a lot of attention because it offers a more sustainable way to grow and build an economy. In this approach, resources are used in a way that makes sure they last as long as possible and creates less waste. One interesting part of the circular economy is the search for different sources of protein that can help make the food system more sustainable. Different kinds of new protein sources that can be used in a model of a circular economy will also be discussed here.

1.2.1 Mycoprotein

Mycoprotein is a protein-rich food that is produced from filamentous fungi (Souza Filho et al., 2019). It is a relatively new protein source that has gained popularity in recent years due to its sustainability, low environmental impact, and high nutritional value (Henchion et al., 2017). Mycoprotein has a meat-like texture and can be used as a substitute for meat in a variety of dishes (Asgar et al., 2010). It is high in protein, fiber, and several micronutrients, making it a healthy addition to the diet (Gomez et al., 2010). Mycoprotein is produced through a fermentation process using a nitrogen-rich medium and can be made from a variety of substrates, including agricultural waste and food processing byproducts (Molfetta et al., 2022). Overall, mycoprotein represents a promising and sustainable alternative to traditional protein sources.

1.2.2 Plant-Based Proteins

Plant-based proteins are often used instead of animal-based proteins because they are better for the earth (De Boer & Aiking, 2011). They need less water and space, and they give off less greenhouse gas. Beans, nuts, seeds, and grains are all good sources of protein that come from plants (Qin, 2022). Legumes like lentils, chickpeas, and beans are especially high in protein and can be used in soups, stews, and salads, among other things (Lonnie & Johnstone, 2020). Nuts and seeds like walnuts, chia seeds, and hemp seeds are also good sources of protein and can be used in baking, smoothies, and as snacks.

1.2.3 Insects

Insects are another form of protein that has become more popular in recent years. Insects are a sustainable way to get protein because they need less water, food, and space than animals (Dobermann et al., 2017). They also have a lot of good things for health, like energy, vitamins, and minerals. Flies, Crickets, mealworms, and grasshoppers are all insects that people often eat (Feng et al., 2018; Wang & Shelomi, 2017). These bugs can be used to make protein bars, snacks, and even food for our pets (Belluco et al., 2013).

1.2.4 Lab meat (Cell-based Protein)

Lab meats or Cell-based proteins are a newer type of protein source that has been made possible by tissue engineering (Stephens et al., 2019). Animal cells are grown in a lab to make these proteins, so there is no need for traditional cattle farming (Takahashi et al., 2022). This way of making protein could make a big difference in how the meat industry affects the environment because it uses less land and water and makes fewer greenhouse gas emissions (Lee et al., 2020). But this technology is still in its early stages of development, so it is not yet available for sale.

1.2.5 Sustainable future through Circular Economy by using meat alternatives

Alternative sources of protein that are better for the environment and the circular economy can help us to build a healthy sustainable world. Along with Mycoprotein, Proteins that come from plants, proteins that come from insects, and proteins that come from cells (lab meat) are all possible sources of protein that can help make the food system more sustainable. Even though there are some challenges with using these alternative protein sources, such as consumer acceptance and scalability at an affordable price for everyone; the potential for these meat alternatives is limitless (Henchion et al., 2017) (Dossey, n.d.). And these problems can be solved with more research and new innovation to make a sustainable future (Lee et al., 2020).

1.3 What is Mycoprotein and How it can be used?

Mycoprotein is a type of protein derived from fungi, specifically the *Fusarium venenatum* strain (Seyed Reihani & Khosravi-Darani, 2019). It was first isolated commercially in the 1960s and has been used as a food source since the 1970s. It is a high-quality protein with a complete amino acid profile and is an important source of dietary fibre. The potential of mycoprotein to be used as a sustainable source of food and feed has been widely studied, and its benefits as a nutrient-dense, low-fat and low-calorie source of protein are well documented (Giavasis et al., 2019). This paper will provide an overview of the current scientific evidence related to mycoprotein as an alternative protein source as food & feed, and we will also discuss the potential implications for its use in various applications.

1.3.1 Mycoprotein as a Food

Mycoprotein is a complete protein, containing all essential amino acids, and is an excellent source of dietary fiber (Boukid et al., 2022). It is low in fat and calories, and a good source of vitamins and minerals also. Because of its beneficial effects on lipid profile, appetite, calorie intake, glycemia, and insulinaemia, mycoprotein is considered a healthy food (Turnbull et al., 1993). Mycoprotein has been used as a meat substitute in vegetarian and vegan diets for many years, as well as being used as a food additive in a wide range of products, such as soups, sauces, and processed foods.

1.3.2 Mycoprotein as a Feed

Mycoprotein can also be used as animal feed, particularly in the poultry and fish farming industries (Becker, n.d.). It is an attractive source of protein for animal feed, since it is relatively cheap, easy to produce, and has a high nutritional value (Becker, n.d.). Mycoprotein is also a good source of essential amino acids, which are important for the growth and development of animals (Bhalla et al., n.d.).

1.4 Potential Benefits of Using Mycoprotein

Mycoprotein, obtained from fungi such as Fusarium venenatum, has gained attention as a sustainable and nutritionally beneficial substitute for protein. These benefits encompass

numerous domains such as human health, environmental sustainability, and economic viability. The potentials are-

High-Quality Protein: Mycoprotein is well-known for its high-quality protein content, which includes all essential amino acids required for human nutrition. The comprehensive nature of this protein source makes it highly valuable for vegetarians, vegans, and those aiming to decrease their consumption of animal-based proteins (Ribeiro et al., 2019).

Nutritional Balance: In addition to protein, Mycoprotein provides a nutritionally balanced profile, including essential vitamins (such as B vitamins) and minerals (such as iron and zinc). The nutritional completeness of the food item contributes to a balanced and comprehensive diet (Matassa et al., 2016)(Ribeiro et al., 2019).

Low Fat Content: Mycoprotein exhibits a naturally low-fat content and is devoid of cholesterol(Denny et al., 2008). This characteristic makes it appealing for individuals seeking to control their fat consumption and enhance cardiovascular health (Savolainen et al., 2002).

Sustainability: Mycoprotein offers a significant advantage in terms of sustainability due to its environmentally friendly production process. According to Schieber et al. (2018), mycoprotein necessitates less land, water, and energy in comparison to conventional livestock farming. Additionally, it produces fewer greenhouse gas emissions, thereby contributing to a diminished carbon footprint (Kapu et al., 2019). This sustainability is in alignment with international initiatives aimed at tackling climate change and the limited availability of resources (E. Derbyshire & Ayoob, 2019).

Reduced Land Use: Traditional agriculture, especially livestock farming, requires large amounts of land for animal rearing and feed production, leading to increased land use. Mycoprotein production takes place in controlled environments, thereby reducing land utilization. Efficiency enables sustainable land management and the preservation of natural ecosystems (Smetana et al., 2015).

Water Efficiency: The production of mycoprotein is more water-efficient compared to conventional meat production(Bajić et al., 2022). The lower water usage per unit of protein makes it a potentially effective solution for areas experiencing water scarcity issues (Hartmann & Siegrist, 2017).

Versatility: Mycoprotein's versatility enables its integration into various culinary contexts. The versatility of this food in different dishes and culinary traditions makes it attractive to consumers with a wide range of dietary preferences (Mintel, 2021).

Allergen-Friendly: Mycoprotein is a suitable option for individuals with food allergies or sensitivities as it is naturally free from common allergens like soy, gluten, and nuts (Liang et al., 2020).

Less Impact on Animal Welfare: Mycoprotein, as a non-animal protein source, addresses concerns regarding animal welfare and ethical considerations in food production (Henchion et al., 2017) (Verbeke et al., 2015).

Potential to Address Food Security: The efficient production of Mycoprotein has the potential to address global food security challenges. The high resource efficiency of this solution makes it a valuable option for addressing the protein needs of a growing global population (Kapu et al., 2019).

In conclusion, Mycoprotein's benefits encompass not only its nutritional quality but also its sustainability, versatility, and potential to mitigate environmental and ethical concerns associated with traditional protein sources. These advantages make Mycoprotein a promising contender in the quest for sustainable and nutritious protein alternatives to meet the demands of a changing world.

1.5 Challenges Associated with the Production and Consumption of Mycoprotein

Along with the potential advantages, there are also several challenges associated with the production and consumption of mycoprotein. The production of mycoprotein can be difficult, as the fungus needs to be grown under controlled conditions in order to produce a high-quality product. Additionally, there are several potential health concerns associated with consuming mycoprotein, such as the potential presence of allergens, the risk of contamination, and the potential for toxic by-products. Furthermore, there is also some concern over the long-term sustainability of mycoprotein production, as it relies on the use of finite resources.

In order to address these challenges, there are several potential solutions. These include the use of genetic engineering to improve the quality and yield of mycoprotein, the use of

fermentation processes to reduce the risk of contamination, and the development of sustainable production methods (Hashempour-Baltork et al., 2020). Moreover, there is an extended need for further research into the potential health benefits and risks associated with the consumption of mycoprotein, as well as further research into the potential environmental impacts of its production. The potential of mycoprotein as an alternative source of protein is considerable, and its use as both a human food and animal feed has the potential to improve food security and nutrition, as well as reduce the environmental impact of animal-based protein production. However, further research is needed in order to address the challenges associated with its production and consumption, in order to ensure its long-term sustainability.

1.6 How Mycoprotein Can Be Produced?

1.6.1 Potential Resources and Substrates for fungus

Mycoprotein is a high-protein dietary supplement derived from filamentous fungi. Mycoprotein is produced by cultivating fungi in a nutrient-rich medium and then harvesting and packaging the harvested fungi (Seyed Reihani & Khosravi-Darani, 2019; Wiebe, 2002).

To develop and synthesize proteins, fungi require a nitrogen-rich substrate, which is provided by a nitrogen-rich medium.

Mycoprotein manufacture usually involves using carbon sources such as glucose, sucrose, and molasses, and nitrogen sources such as ammonium nitrate, ammonium sulfate, or urea (Bajić et al., 2022).

Waste streams from agriculture, such as discarded grains or maize steep liquor, as well as those from the food processing industry, such as whey or soy meal, are also potential substrates for mycoprotein production (Seyed Reihani & Khosravi-Darani, 2019). Despite their high nutritional value, these substrates are a cost-effective alternative to conventional substrates. The production of mycoproteins could benefit from the use of these renewable and environmentally friendly substrates. There are many streams in the agricultural waste stream. Those are-

Potato processing waste: The waste generated during the production of potato chips, french fries, and other potato products can provide carbon and nitrogen for the production of mycoproteins.

Corn cobs and stalks: These waste products from agriculture are full of cellulose and hemicellulose, which can be used to make mycoproteins.

Sawdust and wood chips: These are examples of lignocellulosic materials that are high in cellulose and can be used as substrates for fungi to derive mycoproteins.

Brewery waste: Due to their high protein and carbohydrate content, discarded grains and hops from beer manufacturing can be used as a substrate for mycoprotein production.

Fruit and vegetable waste: Fruit and vegetable peelings and other trash created during processing can be used as a source of carbon and nitrogen for mycoprotein production.

Norwegian Spruce: These trees are abundant in Scandinavia, and Norwegian spruce has a high lignocellulose cellular density, which can be utilized as a substrate for mycoprotein production.

In summary, the potential substrates for mycoprotein production include nitrogen-rich sources such as ammonium nitrate, ammonium sulfate, or urea, as well as carbon-rich sources such as glucose, sucrose, or molasses. Other potential substrates include waste streams from agriculture or food processing industries, as well as unconventional substrates such as seaweed, algae, and lignocellulosic biomass.

1.6.2 Potential Fungus that grows there

The most common fungal species employed in the production of Mycoprotein is *Fusarium venenatum* spp (O'Donnell et al., 1998; Wiebe, 2002). The aforementioned fungus has garnered significant attention as the predominant provider of Mycoprotein, primarily owing to its compatibility with extensive fermentation procedures and its established safety for human ingestion.

Why Fusarium venenatum?

Efficient Growth: Fusarium venenatum demonstrates a notable capacity for converting carbohydrates into biomass that is rich in protein, thereby exhibiting high efficiency in growth (Barzee et al., 2021; Coelho et al., 2020). Rai et al., (1985) had depicted that the maintenance of this particular attribute is of utmost importance in the production of Mycoprotein, as it guarantees a substantial protein output throughout the course of fermentation.

Safety: Extensive research has been conducted on this fungus, providing substantial evidence to support its safety for human consumption. This microorganism is labeled as GRAS (Generally Regarded as Safe). According to Lacey et al. (1988), the organism in question does not generate mycotoxins or any other detrimental substances that could potentially endanger consumers.

High-Quality Protein: *Fusarium venenatum* is capable of producing a protein that possesses a high nutritional value, as it contains all the essential amino acids necessary for human dietary requirements (Hynes & Pateman, 1985).

1.6.3 Mycoprotein Industrial Production

The industrial production of mycoprotein involves several stages. The selection and cultivation of the fungus is the first stage. The *Fusarium venenatum* strain used to produce mycoproteins is chosen based on its growth rate, yield, and nutritional value (Seyed Reihani & Khosravi-Darani, 2019). The fungus is then grown in large fermenters under controlled temperature, pH, and oxygen levels. During the fermentation process, which lasts approximately 7 to 10 days, the fungus consumes the provided nutrients and produces mycoprotein biomass (Bajić et al., 2022, 2022).

Through centrifugation or filtration, the mycoprotein biomass is separated from the fermentation fluid following fermentation. The mycoprotein biomass that results is then washed, dried, and powdered into a fine powder. The powder can be used directly as a meat substitute or processed into a variety of mycoprotein-based culinary items, including burgers, sausages, and nuggets.

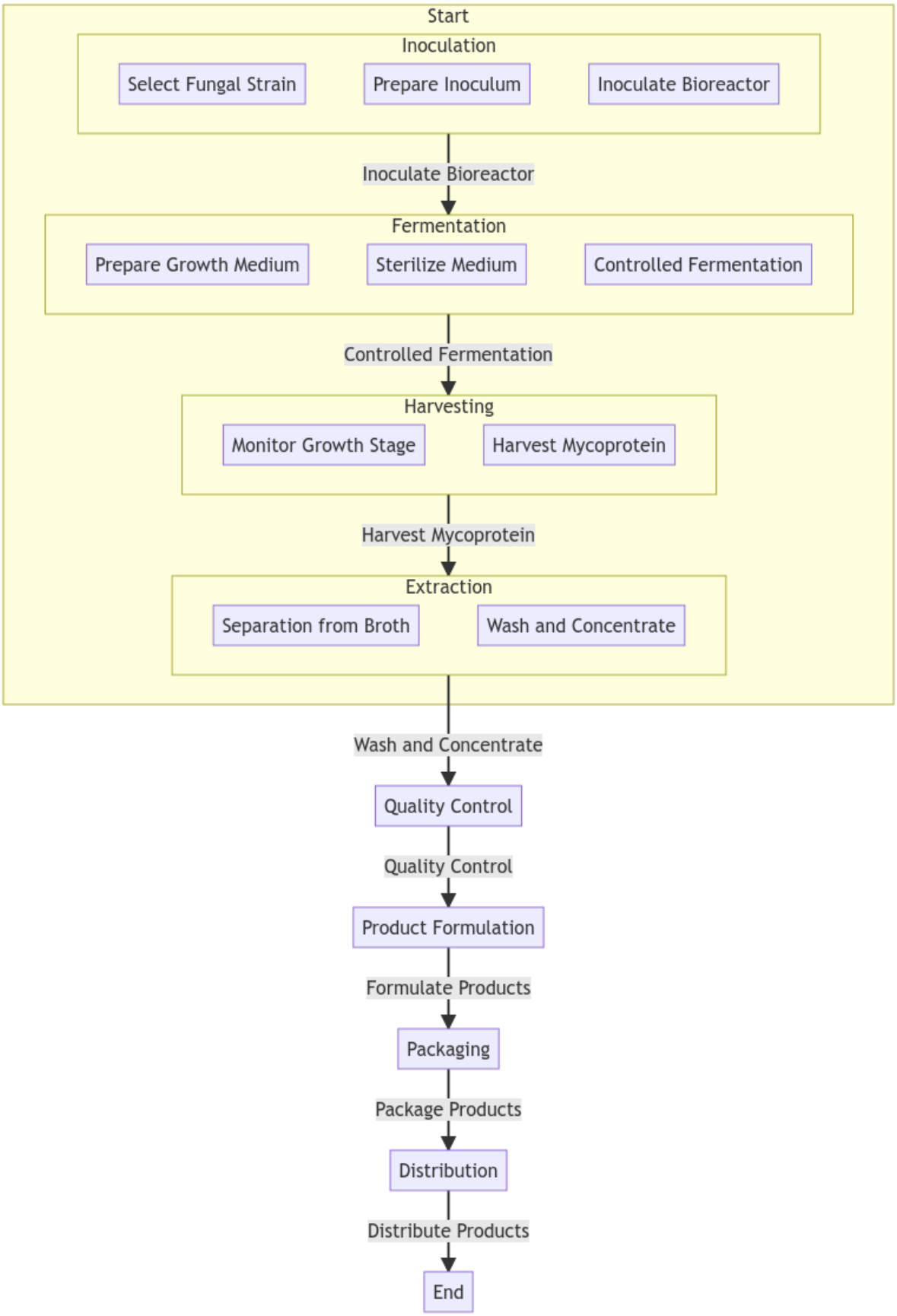


Figure 1: Simplified production stages of Mycoprotein

Key Factors in Production

Temperature: The ideal range for mycoprotein fermentation is between 28 and 30 degrees Celsius, though some strains may benefit from a different temperature.

pH: For the production of mycoproteins, a slightly acidic pH in the range of 4.5 to 5.5 is essential (Hosseini et al., n.d.).

Dissolved Oxygen: Sufficient levels of dissolved oxygen are necessary for the growth of fungi and the synthesis of mycoprotein. Aeration and agitation are used to guarantee an adequate supply of oxygen.

Fermentation Kinetics: Process optimization requires an understanding of the kinetics of mycoprotein fermentation. The study of fermentation kinetics entails tracking the development of *Fusarium venenatum* and the progressive build-up of biomass from mycoproteins. Kinetic models and growth curves are useful tools for forecasting and enhancing mycoprotein yield.

1.6.4 Challenges while Scaling up Mycoprotein and Solution

The process of transitioning Mycoprotein production from a small-scale laboratory setting to a large-scale industrial operation poses some substantial hurdles that must be overcome in order to successfully bring Mycoprotein products to the commercial market. Scaling up Mycoprotein production is a complex endeavor, but it is essential for meeting the growing demand for sustainable protein sources while maintaining product quality and consistency (Upcraft et al., 2021).

This section examines the various challenges and solution strategies associated with the aforementioned process.

Challenges in Scaling Up

Several challenges must be addressed when scaling up Mycoprotein production. Those are-

- Maintaining Consistency: Ensuring product consistency and quality on a larger scale.
- Optimizing Fermentation: Scaling up fermentation processes while maintaining control and efficiency.
- Resource Availability: Securing sufficient raw materials and resources for large-scale production.
- Infrastructure and Facilities: Developing and optimizing the infrastructure for industrial-scale production, including bioreactors and processing facilities.

Solution Strategies for those challenges

To overcome these challenges, strategies include:

- Process Optimization: Continuously refining and optimizing Mycoprotein production processes to ensure scalability.
- Automation: Implementing automation and control systems to maintain consistent fermentation conditions.
- Supply Chain Management: Developing a robust supply chain to secure raw materials and logistics for large-scale production.
- Regulatory Compliance: Ensuring compliance with regulatory requirements and standards for food safety and quality.
- Research and Development: Ongoing R&D efforts to adapt and improve production methods for industrial-scale operations.

1.7 Aim(s) of the study

The aim of the thesis is to explore the potential of Mycoprotein as an alternative source of protein while comparing with other alternatives and to perform an in-depth analysis to make a business plan for setting up a mycoprotein production factory.

1.8 Objective(s) of the study

- ✓ To explore the potential of Mycoprotein being a new source of protein as food and feed.
- ✓ To compare Mycoprotein with other new sources of protein such as insects and lab-meats.
- ✓ To evaluate the technology for mycoprotein production on an industrial basis.
- ✓ To assess the possibilities and challenges of setting up a Mycoprotein production factory in Norway.
- ✓ To perform a market analysis and develop a business plan for setting up a Mycoprotein factory.

1.9 Research Questions

- ➢ What are the potential benefits of using Mycoprotein as food and feed?
- ➢ What are the different substrates which can be used in mycoprotein production?
- ➢ What are the possibilities and challenges that might come up while setting up a Mycoprotein production factory?
- ➢ What are the different market segmentations for Mycoprotein?
- ➢ What could be the beach head market for Mycoprotein?
- ➢ What is the value chain for Mycoprotein?
- ➢ What could be the most profitable business model for a Mycoprotein production company?
- ➢ How the business model would be able to impact future sustainability?

2. Material and Methods

Both primary and secondary sources will be used during research and data collection.

2.1 Database search

Secondary sources were existing documents like review articles, research articles, case studies, reports, and books. Several online data sources were studied to collect the statistical data and information. The search terms “Mycoprotein”, “alternative protein source”, “Mycoprotein as food and feed”, “Mycoprotein as sustainable protein source”, “fusarium venenatum”, “fungal mycelium”, “fungal protein” and various other words such as; production, potential, challenges, market analysis, business model canvas, etc.; were used in combination. The search tool available in Høgskolen i Innlandet database search engine Oria was used to find the relevant articles, eBooks, journals, thesis, and books related to the topic. Several other search engines like Google Scholar, Science Direct, Springer Link, ACADEMIA, ResearchGate, and NCBI were used during the research. Both primary and secondary sources were used during research and data collection.

2.2 Interview

Key Informants Assessment (KIA) was conducted during the research work to collect data for market survey and building end-user profile.

2.3 Tools Used for Market Analysis

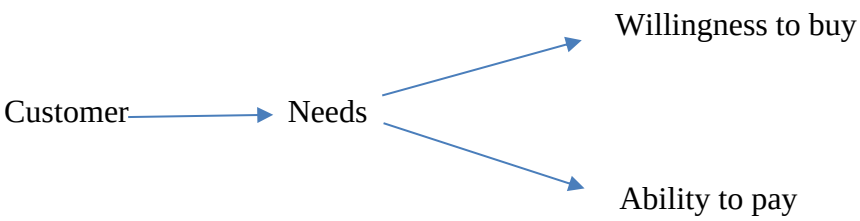
Below mentioned methods shall be used to analyse the Mycoprotein market.

2.3.1 Market Segmentation

Finding customers is the main focus of market segmentation. The fundamental principle of market segmentation is to create distinct market groups based on client needs, willingness, and ability to buy (Dean et al., 2022). We must determine the criteria that distinguish one market niche from another. Segmentation factors, on the other hand, must be quantifiable. Customer demands and product-related behavior should be linked to segmentation characteristics.

Market segmentation is the process of dividing a large group of similar potential customers into distinct subgroups. Customers are classified according to whether they match specific requirements or have other qualities that cause them to seek out the same products. Customers in each segment respond similarly to marketing strategies. They share identical needs, objectives, and interests.

Most businesses do not have the financial resources to market to a large clientele. Therefore As a result, enterprises must target the market group that has a demand for their product. As a result, the company may concentrate on delivering the value proposition to a certain consumer niche in order to develop a beachhead market that will eventually generate enough revenues which will help them to sustain. In summary, Market segmentation divides the market into easily recognized, connected groups.



2.3.2 Beachhead Market selection

A Beachhead approach is a strategy in which promoters attempt to establish a distinct, well-defined client segment who will likely be the first to purchase the new product or service. It offers a structure for sales and marketing focus, customer interaction, and resource allocation. It is a concept taken from a military strategy that recommends planning and focusing all of your efforts on capturing a tiny border area that serves as a foothold from which to push into combat zones as you approach enemy territory (Aulet, 2013).

2.3.3 End User Profiling

End user profiling is the process of learning about the people who will actually use the system and making a profile of them based on their age, gender, socioeconomic background, (dis)abilities, knowledge, skill set, frequency of use, areas of interest, and any other supporting documentation (Aulet, 2013).

2.3.4 Competitive Analysis and Product Positioning

Different kinds of research and databases were used to look at competitors and the market situation. Product positioning is a type of marketing in which the benefits of your product are shown to a specific group of people who are likely to buy it. In normal words, product positioning refers to the key attributes that differentiates your product from other competitors.

2.3.5 Total Accessible Market (TAM) Analysis

Total Addressable Market (TAM) refers to the maximum size of the potential market for a specific product or service. In other words, TAM enables us to understand how large the market would be if everyone who might conceivably find value in a product or service bought/began using it.

2.3.6 Value Proposition

A value proposition is a promise to offer value. It is the main reason a customer should purchase this product. In summary, a value proposition is a straightforward statement that describes how this product solves the consumers' problem, or provides unique benefits, and explains to the ideal consumer why they should buy this from you instead of the rival. (Chai, 2022).

2.3.7 Value Chain Analysis

The term "value chain" refers to the series of interconnected stages in the production of a good or service, from the acquisition of raw materials through the final sale. It is a process which shows that how the value is added into a product or service.

2.3.8 Market Survey

A market survey is the research and analysis of a certain product or service's market, including the investigation of consumer preferences. A study of several customer attributes, including economic characteristics and purchasing potential. Market surveys are techniques for collecting direct feedback from the target audience in order to comprehend their characteristics, expectations, and needs.

2.3.9 Unique Selling Proposition

Unique Selling Proposition, also known as USP, is the characteristic of a product or the perceived benefit that sets it apart from the other competing brands on the market. A customer will be driven to purchase a product for this very reason, in spite of the fact that it may be

more expensive than similar products in the market. In plain words, USP is the attribute of a product that distinguishes it from similar products of rivals who are competing for the same customer segments.

2.3.10 Distribution

Distribution is the process of dispersing a product or service throughout the market in such a way that a large number of consumers are able to purchase it. Distribution is very crucial to the success or failure of a business. In simple words, if an organization has an effective distribution system, it raises the likelihood that it will sell more of its own products than its rivals.

2.3.11 Business Model Canvas

Alex Osterwalder is the one who came up with the idea for the Business Model Canvas. The business model canvas is a wonderful tool that provides a straightforward and organized method for obtaining a comprehensive understanding of a company's business insights. By using this canvas, we can gain insights and information relating to the customers that the company serves, the different value propositions that are offered and the channels through which they are offered, as well as how the company makes money. The business model canvas can also be used to understand the rival's business model.

2.3.12 SWOT Analysis

When developing a business strategy, whether for a new venture or to direct an existing organization, conducting a SWOT analysis is a tool that is both incredibly straightforward and highly effective.

The acronym SWOT analysis of a company refers to a company's "Strengths, Weaknesses, Opportunities, and Threats" analysis.

Both the company's strengths and weaknesses are things that are under the company's direct control and are subject to modification. Some examples are the members of your team, product positioning, USP, patents and other forms of intellectual property, as well as the location of your business etc. Opportunities and threats are external factors that are taking place in the larger market and are not related to the company itself. It is possible to take advantage of opportunities and protect yourself from danger, but these factors cannot be altered. Examples of this would be the prices of raw materials, the prices of competitors, the shopping trends of customers, laws & legislation of a specific country etc.

2.3.13 PESTEL Analysis

The PESTEL analysis, alternatively referred to as the PESTLE analysis, is a strategic framework employed by organizations to assess and evaluate the external macro-environmental factors that possess the potential to influence their business operations, decision-making processes, and strategic planning endeavours. The acronym "PESTEL" represents a framework that encompasses the analysis of various factors, namely Political, Economic, Sociocultural, Technological, Environmental, and Legal, which are influential in shaping and understanding the business environment. Through systematic investigation of these crucial elements, enterprises acquire valuable understanding of the external influences and patterns that could potentially impact their industry, market, and broader business ecosystem.

3. Result and Discussion

3.1 Head-to-head comperative analysis of Mycoprotein, Lab Meat (Cultured Meat) and Insect Protein

In the quest for sustainable protein sources, a range of alternatives to conventional meat have surfaced, which includes Mycoprotein, lab-cultured meat, and insect protein. This comparative analysis explores the head-head analysis based on significant factors, including sustainability, climate impact, price per kilogram, nutritional value, water consumption, and land usage.

Aspect	Mycoprotein	Lab Meat	Insect Protein
Sustainability	Lowest environmental impact	Lower carbon footprint	Efficient resource use
Climate Impact	Very low greenhouse gas emissions	Low greenhouse gas emissions	Lower emissions
Price per kg	Price varies	Currently higher cost	Cost-effective
Nutritional Value	High-quality protein, low fat	Mimics traditional meat	Rich in nutrients
Water Use	Relatively low	Varies by production method	Highly efficient
Land Use	Minimal land required	Minimal land usage	Small land footprint

Figure 2: Head-to-Head comparison of Mycoprotein vs Lab Meat vs Insect Protein

Sustainability and Climate Impact

Mycoprotein has gained recognition as an environmentally conscious alternative due to its minimal ecological footprint and diminished release of greenhouse gases. The utilization of agricultural waste can be done in an efficient manner to produce mycoprotein.

The production of lab-grown meat demonstrates a reduced carbon footprint in comparison to traditional methods of meat production, although it may still entail a significant consumption of energy.

The utilization of insect protein showcases its high resource efficiency, as it emits fewer greenhouse gases and thus contributes to the overall sustainability of our ecosystem.

Price per kg and Nutritional Value

Mycoprotein, as a food ingredient, presents a compelling value proposition due to its competitive pricing and notable nutritional advantages, such as its provision of high-quality protein while maintaining low levels of fat and cholesterol.

Lab-grown meat, despite its objective of mimicking the nutritional composition of conventional meat, presently requires higher production expenses.

The utilization of insect protein presents a cost-effective and nutritionally dense alternative, despite the potential variation in nutrient composition across different insect species.

Water and Land Use

Mycoprotein, due to its water-efficient nature and ability to minimize land requirements, demonstrates suitability for everywhere. The production of lab-grown meat necessitates significantly less land and water resources in comparison to conventional meat production.

The utilization of insect protein showcases the remarkable efficiency of insects in terms of their water and land usage, thereby making a significant contribution to the overall sustainability efforts.

In an in-depth comparative analysis, it is evident that each alternative protein source presents distinct advantages. We can easily say that Mycoprotein stands out for its very little environmental footprint, effective utilization of resources, cost competitiveness, and enticing nutritional composition. Both lab-grown meat and insect protein exhibit promising

characteristics, such as decreased environmental impacts and cost efficiency, but Mycoprotein is the winner by a far margin in this head-to-head comparison based on these factors.

3.2 Market segmentation

3.2.1 Market segmentation based on End User:

1. Health-conscious consumers who are looking for sustainable protein sources
2. Vegan & Flexitarians
3. Environmentally conscious consumers
4. Food manufacturers
5. Athletes and Fitness enthusiasts

Health-conscious consumers who are looking for sustainable protein sources: The first type consists of health-conscious consumers looking for sustainable protein options that are low in fat and high in protein without the use of any common allergens. The marketing of mycoprotein to this group can help them get all the protein they need without eating meat.

Vegan & Flexitarians: This segment consists of consumers who follow a vegan or vegetarian diet and seek plant-based sources of protein. Mycoprotein is an alternative protein source that can be incorporated into a variety of vegan and vegetarian dishes, including burgers, sausages, and stews.

Environmentally conscious consumers: This segment of consumers is concerned about the environmental impact of animal agriculture and seeks out sustainable sources of protein. Mycoprotein has a lower footprint on the environment than conventional meat products and can be marketed to this market as a means of reducing their environmental impact.

Food manufacturers: This market segment includes companies that manufacture baked goods, snacks, and meat substitutes. Mycoprotein can be marketed to food manufacturers as a versatile and sustainable protein source and used as an ingredient in an extensive range of food products.

Athlete and Fitness Enthusiasts: This market segment consists of consumers who want to gain muscle and live a healthy lifestyle while doing yoga or exercise to stay fit. Mycoprotein is a high-protein supplement that can be marketed to this market segment to meet nutritional needs while also promoting fitness goals.

3.3 Beachhead Market for Mycoprotein

The beachhead market segment for mycoprotein would depend on several factors, including the availability of raw materials, production capacity, product acceptability, distribution channel, regulatory frameworks, consumers need, ability to pay and willingness to buy.

However, a potential beachhead market segment for mycoprotein could be the health-conscious people who are looking for sustainable protein sources, especially for the reason of nutrition benefit and social awareness. Mycoprotein has several advantages over other meat substitutes such as soy, wheat, and pea protein, on the market for alternative protein source. Mycoprotein is a source of complete protein, and its meat-like texture makes it suitable for being utilized as meat substitutes. In addition, the production of mycoproteins requires less land, water, and energy than conventional meat production and cultivation of vegan proteins, making it a more sustainable and environmentally favorable alternative.

Targeting the market segment of health-conscious people as a beachhead market could assist mycoprotein companies in establishing a foothold in the market and building brand recognition among health-conscious and environmentally conscious consumers. The market for alternative source of protein is also expanding significantly, as an increasing number of consumers are choosing alternatives to meat. Mycoprotein companies can expand into food service, retail, and ingredient markets as demand for meat alternatives continues to rise day by day

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3.4 End user persona for Mycoprotein

Name: Merina Eide

Age: 34

Occupation: Marketing Manager

Lifestyle: Merina leads an active lifestyle and enjoys cooking and trying new foods. She values sustainability and is mindful of her carbon footprint. Merina has a busy schedule and often looks for convenient, healthy meal options.

Motivations and Goals: Merina is looking for a plant-based protein source that is healthy, sustainable, and easy to incorporate into her busy lifestyle. She wants to reduce her meat consumption without sacrificing the taste and texture of meat-based dishes.

Challenges and Pain Points: Merina has tried other plant-based meat alternatives in the past, but has found them to be lacking in taste and texture. She is also concerned about the environmental impact of traditional meat production and wants to make more sustainable food choices, but is unsure about the options available to her.

Buying Behavior: Merina is willing to pay a premium for high-quality, sustainable food products. She is open to trying new and innovative food products but requires convenience and ease of use in her busy lifestyle. She values product transparency and wants to know where her food comes from and how it is produced.

By understanding the motivations, goals, challenges, and buying behavior of end users like Merina, we can tailor our marketing strategies and product offerings to meet the needs and preferences of the target market.

Watering Hole: Merina often visits a local health food store after her workouts, where she likes to browse the selection of plant-based protein sources and supplements. She also follows several health and wellness bloggers and influencers on social media, who frequently share recipes and reviews of plant-based food products. Merina occasionally attends local food festivals and events focused on sustainability and plant-based diets, where she can try new foods and learn more about the latest trends in the industry.

Priorities:

Health: Merina prioritizes her health and looks for plant-based protein sources that are nutritious and support her active lifestyle.

Sustainability: Merina is concerned about the environmental impact of traditional meat production and wants to make more sustainable food choices.

Taste and Texture: Merina enjoys meat-based dishes and wants to find plant-based alternatives that taste good and have a similar texture to meat.

Convenience: Merina has a busy schedule and wants to find plant-based protein sources that are easy to incorporate into her daily routine.

Price: While Merina is willing to pay a premium for high-quality, sustainable food products, price is still a consideration in her purchasing decisions.

Proxy Products:

Plant-Based Protein Powders: Merina may be interested in plant-based protein powders, which are a convenient and versatile way to add protein to her diet. Many plant-based protein powders are made from mycoprotein or other plant-based sources, making them a good proxy product for mycoprotein-based meat alternatives.

Tofu and Tempeh: These soy-based products are common meat alternatives and have a similar texture to meat. While they may not be as sustainable as mycoprotein, they are a good proxy product for taste and texture.

Meatless Burgers: There are several brands of meatless burgers on the market, many of which are made with mycoprotein or other plant-based protein sources. These products can be a good proxy for mycoprotein-based meat alternatives, as they offer a similar taste and texture to meat.

Plant-Based Meal Kits: Merina may be interested in plant-based meal kits, which offer a convenient and easy way to incorporate more plant-based protein sources into her diet. Many of these meal kits include mycoprotein-based meat alternatives, making them a good proxy product.

3.5 Value Proposition

Mycoprotein is a meat alternative that offers tremendous nutritional benefits, sustainability, texture and taste, versatility, and potential health benefits in a single ingredient.

“A sustainable, highly nutritious, easily digestible protein alternative that will give the taste of meat.”

Slogan: “Let’s build a sustainable hunger-free world by making right choice on food & nutrition”

3.6 Value Chain Analysis

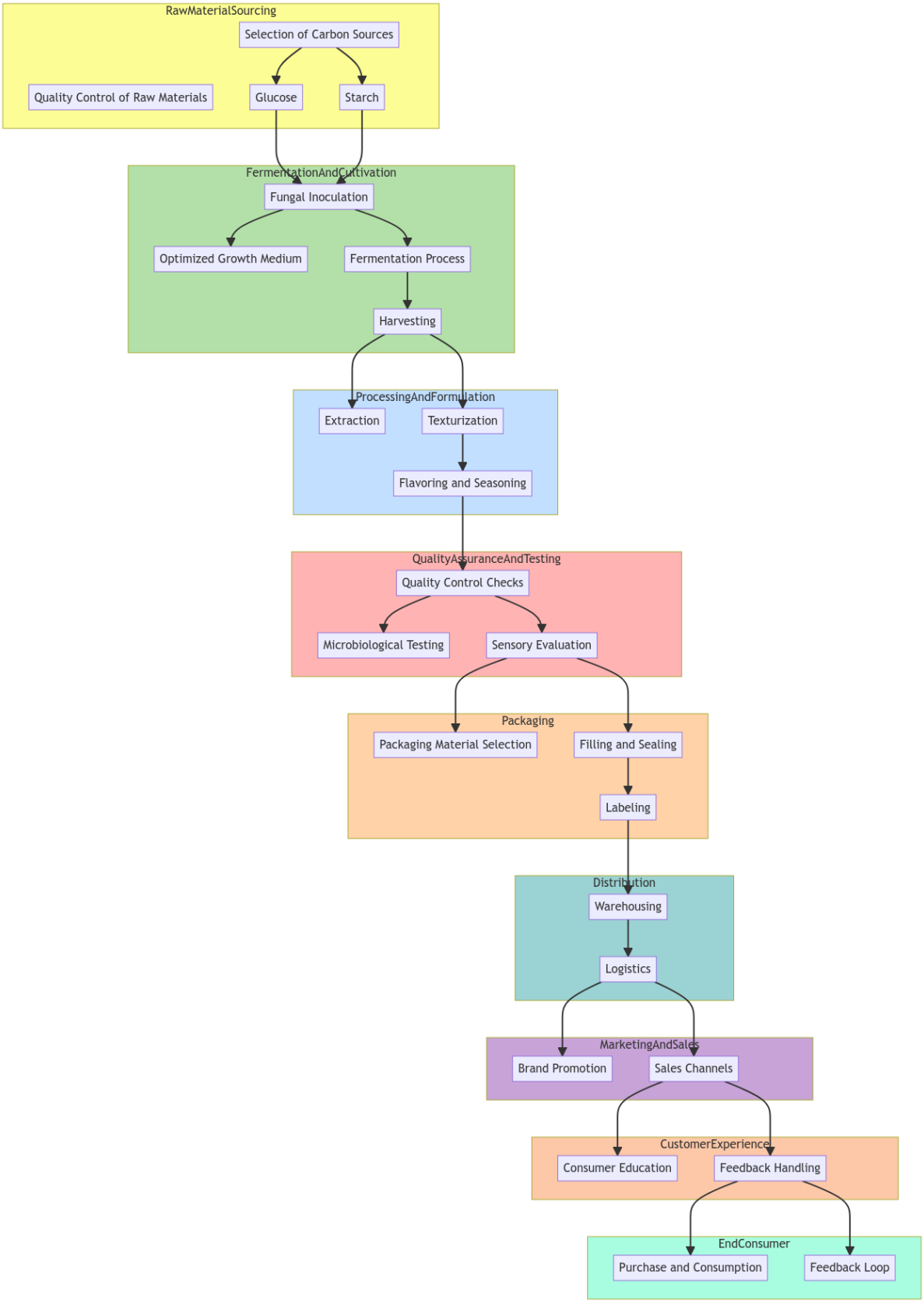

Figure 3: High-level specific Value Chain Analysis of Mycoprotein

Figure 4: Simplified Value Chain Analysis of Mycoprotein

The value chain analysis for Mycoprotein products provides a comprehensive overview of the main stages and processes involved in the production and distribution of products derived from Mycoprotein. The steps in value chain of mycoprotein are-

3.6.1 Raw Material Sourcing

Primary Source: Primary sources for Mycoprotein production include glucose, starch, and other renewable carbon sources.

Quality Control: Quality control involves the rigorous testing and adherence to regulatory standards to ensure the quality and purity of raw materials.

3.6.2 Fermentation and Cultivation

Fungal Inoculation: Fungal inoculation involves introducing a specific fungus, such as Fusarium venenatum, known for its ability to produce mycoprotein, into the fermentation vessel.

Growth Medium Preparation: Growth Medium Preparation involves the formulation of a nutrient-rich medium with appropriate mineral composition and pH regulation to facilitate optimal fungal growth.

Fermentation: Fermentation involves cultivating the fungus and facilitating the production of Mycoprotein through carefully regulated conditions such as temperature, aeration, and agitation.

Harvesting: Harvesting involves the separation of Mycoprotein biomass from the fermentation broth through methods such as centrifugation or filtration.

3.6.3 Processing and Formulation

Extraction: Extraction involves the isolation and concentration of Mycoprotein from the biomass that has been harvested.

Texturization: Texturization refers to the process of utilizing specialized equipment to achieve specific textures and forms, such as chunks, mince, or fillets.

Flavoring and Seasoning: The addition of flavors, spices, and seasonings to Mycoprotein products enhances their taste and versatility.

3.6.4 Quality Assurance and Testing

Quality Control: Quality control involves performing thorough checks to ensure that safety, taste, texture, and nutritional content adhere to specified standards.

Microbiological Testing: Microbiological testing is conducted to screen for contaminants and pathogens in order to ensure the safety of the product.

Sensory Evaluation: Sensory evaluation involves the use of organoleptic testing methods to assess the taste, aroma, and texture of a product.

3.6.5 Packaging

Packaging Material Selection: The process of choosing suitable packaging materials, including eco-friendly options, to preserve product freshness and prolong shelf life.

Filling and Sealing: The process of packaging Mycoprotein products involves filling and sealing them in different formats, such as trays, pouches, or bulk packaging.

Labeling: Labeling involves the application of essential product information, such as ingredients, nutrition facts, and branding.

3.6.6 Distribution

Warehousing: Warehousing involves the storage of finished products in distribution centers, ensuring that appropriate temperature and humidity conditions are maintained.

Logistics: Logistics involves the efficient management of transportation and distribution channels to ensure the prompt delivery of goods to retailers, wholesalers, or end consumers

3.6.7 Marketing and Sales

Brand Promotion: Creating marketing strategies to promote Mycoprotein products, highlighting their sustainable nature, health advantages, and versatility.

Sales Channels: Forming distribution agreements with retailers, foodservice providers, and e-commerce platforms.

3.6.8 Customer Experience

Consumer Education: Informing consumers about the advantages of Mycoprotein and its integration into dietary practices.

Feedback Handling: The feedback loop involves the integration of consumers' experiences and feedback into the value chain, which subsequently influences product development and marketing strategies.

3.6.9 End User

Purchase and Consumption: Consumers acquire Mycoprotein products and utilize them in diverse culinary applications.

Feedback Loop: Consumers' experiences and feedback loop back into the value chain, influencing product development and marketing strategies.

3.7 TAM (Total Addressable Market) Analysis

The process of determining a precise estimation of the Total Addressable Market (TAM) for mycoprotein in Norway needs a thorough investigation and evaluation of multiple factors and market segments. Although obtaining exact figures may prove difficult, it is possible to generate reasonable approximations by utilizing existing data and making certain assumptions.

According to surveys and research data, Norway has a population around 5.4 million. An estimated 6-8% of the Norwegian population self-identifies as following to a vegetarian or vegan dietary lifestyle. Also, a small proportion of individuals adhere to flexitarian diets, intermittently integrating plant-based alternatives into their dietary choices. According to estimates, approximately 20-25% of the Norwegian population has either decreased their meat intake or actively pursues alternatives to meat. And approximately 15-20% of the population can be classified as health and fitness enthusiasts who place a high emphasis on the consumption of protein.

For the convenience of calculation, let's assume that total population in Norway is 5 million and at least 25 % of them are either vegan, flexitarian or health-conscious people. And if on average, each person allocates approximately 2000 Nok annually for the procurement of protein sources. Then,

TAM = Total population x annual expenditure = 5,000,000 x 2000 Nok = 10 billion Nok.

However, everyone is not going to buy meat alternatives and that's why SAM (Serviceable Addressable Market) will be 25% of TAM. So, SAM= 25% x TAM = 2.5 billion Nok.

And SOM (Serviceable Obtainable Market) would be the market which we can cover. If we assume that we want 1% of SAM, then the SOM will become 25 million Nok. This will be the revenue we want from covering the market share by providing Mycoprotein.

3.8 SWOT Analysis

Strength	Weakness
1. Nutritious & High Fiber content 2. Sustainable 3. Versatile 4. Growing demand 5. Technology advancements	1. Limited Availability 2. Product complexity 3. Limited variety 4. Allergen
Opportunity	**Threat**
1. Expansion of business 2. Further Innovation 3. Partnership 4. Aid from government and NGOs	1. Competition 2. Rules & Regulation 3. Customer Perception 4. Supply chain disruption

Figure 5: SWOT analysis of Mycoprotein Production

3.8.1 Internal Factors

Strengths

Sustainability: The production of mycoprotein is considered to be environmentally sustainable due to its lower resource consumption in comparison to conventional livestock farming practices. This includes reduced utilization of water, land, and energy (Schieber et al., 2018).

Nutritional Value: The nutritional value of mycoprotein is notable due to its high-quality protein content, characterized by a favorable amino acid profile and low-fat content, as demonstrated by Ribeiro et al. (2019).

Consumer Acceptance: The potential for consumer acceptance can be enhanced by raising awareness regarding the advantages of sustainability and health, as suggested by Hartmann and Siegrist (2017).

Technology Advancements: The efficiency of Mycoprotein production can be enhanced through technological advancements in fermentation and biotechnology (Aro et al., 2019).

Weaknesses

Limited Variety: The current selection of Mycoprotein-based products is limited, which may restrict their market appeal (Smetana et al., 2015).

Production Complexity: The production of Mycoprotein is characterized by a multi-step fermentation process that necessitates the utilization of specialized equipment and expertise (Koutinas et al., 2017).

Regulatory Challenges: The introduction of mycoprotein into the market presents regulatory challenges, as the process of obtaining approval within existing frameworks can be both time-consuming and characterized by a degree of uncertainty (Jribi et al., 2020).

3.8.2 External Factors

Opportunities

Rising Demand: The escalating global demand for alternative protein sources presents a substantial growth prospect (Verbeke et al., 2015).

Health and Sustainability Trends: The increasing recognition of health and sustainability concerns has the potential to influence consumer inclination towards Mycoprotein (Kearney, 2010).

Diversification: Diversification entails the expansion of Mycoprotein product offerings to accommodate various consumer segments, including vegans, vegetarians, and flexitarians (Mintel, 2021).

Threats:

Competition: Competition in the alternative protein market is observed, as evidenced by the presence of diverse options such as insect-based proteins and lab-grown meats (Lynch et al., 2020).

Supply Chain Disruptions: The susceptibility of supply chains to disruptions, such as variations in the accessibility of essential substrates for the production of Mycoprotein, has been identified by Zhu et al. (2019).

Consumer Skepticism: Consumer skepticism refers to the apprehensions and reservations that individuals may have regarding the safety and acceptability of newly introduced food products. These concerns have the potential to significantly impact the extent to which consumers are willing to adopt and incorporate such products into their dietary choices (Siegrist et al., 2018).

Environmental Impact Critiques: Critiques on the Environmental Impact: Notwithstanding the sustainability benefits it offers, the production of Mycoprotein may encounter scrutiny pertaining to its ecological ramifications (Hoek et al., 2011).

3.9 PESTEL Analysis

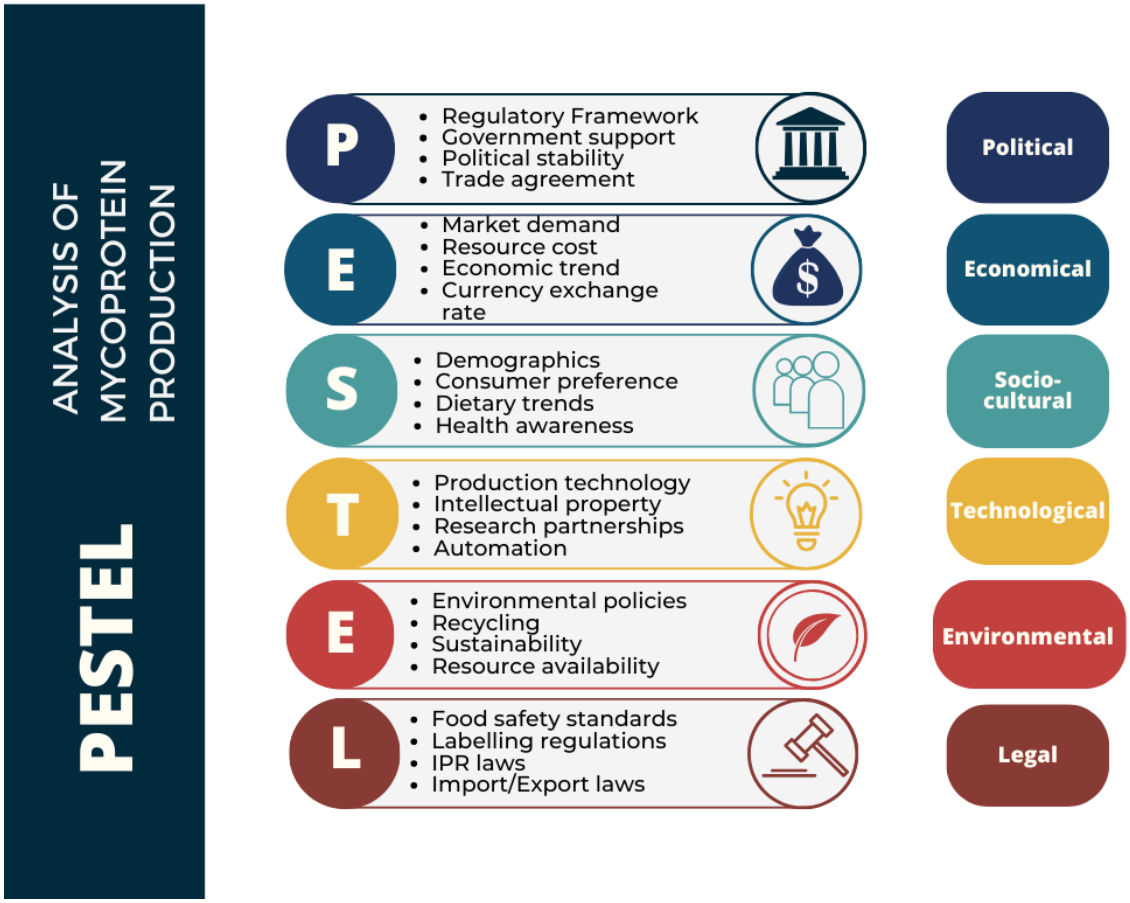

Figure 6: PESTEL analysis of Mycoprotein production business

3.9.1 Political Factors

1. Regulatory Framework: Compliance ensures product safety and market access. The adherence to food safety and environmental regulations is of utmost importance for a Mycoprotein production company in order to guarantee consumer safety and mitigate environmental consequences (Smith, 2019, "Food Safety Regulations and Compliance").

2. Government Support: Grants and incentives promote growth in sustainable industries. The provision of government support, in the form of grants and incentives, has the potential to exert a substantial impact on both the initial capital investment and the subsequent growth of sustainable food production sectors (European Commission, 2021, "Grants and Incentives for Sustainable Food Production").

3. Political Stability: A stable political environment reduces investment risks. Political stability plays a crucial role in mitigating investment risks and fostering a favorable business environment (World Bank, 2021, "Political Stability and Investment").

4. Trade Agreements: Trade agreements may impact import/export of raw materials. The import and export of raw materials utilized in Mycoprotein production can be influenced by international trade agreements, thereby requiring a comprehensive comprehension of trade regulations (World Trade Organization [WTO], 2021). Since Norway has several trade agreements with other countries, those agreement will influence directly and indirectly.

3.9.2 Economic Factors

1. Market Demand: Evaluate the size and growth potential of the alternative protein market. The assessment of the magnitude and prospective expansion of the alternative protein market holds significant importance in facilitating well-informed investment choices (Grand View Research, 2021, "Alternative Proteins Market Size, Share & Trends Analysis Report").

2. Resource Costs: Efficient sourcing and utilization of raw materials are cost critical. The cost of resources is a crucial factor in maintaining competitiveness, as efficient sourcing and utilization of raw materials play a significant role (Riggirozzi, 2019, "Resource Development, State Policies and Economic Growth").

3. Economic Trends: Monitor economic shifts that may affect consumer spending. It is really important to monitor economic fluctuations, such as recessions or economic upturns, as they have the potential to influence consumer expenditure on high-quality food items (UNCTAD, 2021, "Economic Trends and Prospects").

4. Currency Exchange Rates: Exchange rate fluctuations can impact international trade. The volatility of currency exchange rates can have an impact on the expenses associated with the importation or exportation of raw materials and goods, necessitating the implementation of a risk management approach (PwC, 2021, "Managing Foreign Exchange Risk").

3.9.3 Sociocultural Factors

1. Consumer Preferences: Understand cultural preferences for protein sources. The comprehension of cultural preferences for protein sources is crucial in order to customize marketing strategies and product offerings (Hofstede, 2001)

2. Health Awareness: Health-conscious consumers drive demand for nutritious options. The growing awareness of health-consciousness among consumers is a key factor contributing to the rising demand for nutritious protein alternatives such as Mycoprotein (Glanz et al., 2008).

3. Dietary Trends: Assess dietary habits and trends influencing protein choices. Staying updated on dietary trends and changes in consumer preferences, such as the adoption of plant-based diets or flexitarianism, can provide valuable insights for product development (Harvard Health Publishing, 2021, "Becoming a Vegetarian").

4. Demographics: Consider age and lifestyle factors affecting consumption patterns. Demographic variables, such as age and lifestyle, exert an influence on consumption patterns, underscoring the significance of comprehending target markets (BLS, 2021, "Consumer Expenditures—2019").

3.9.4 Technological Factors

1. Production Technology: Adopting advanced biotechnology is crucial for efficient production. The implementation of sophisticated biotechnology and fermentation techniques is crucial in achieving optimal and environmentally friendly Mycoprotein synthesis (Stamets, 2005, "Mycelium Running: How Mushrooms Can Help Save the World").

2. Research Partnerships: Collaborating with research institutions for innovation. The continuous pursuit of innovation in research and development is crucial for maintaining competitiveness. According to the National Academies of Sciences, Engineering, and Medicine (2018), engaging in research partnerships with academic institutions can facilitate advancements in Mycoprotein production techniques and the development of related products.

3. Automation: Implementation of automation to optimize production processes. The integration of automation into production processes has the potential to enhance operational

efficiency, decrease production expenses, and guarantee the uniformity of products (Davenport, 2018).

4. Intellectual Property: Protection of proprietary production methods through patents and copyrights. The safeguarding of a company's unique technology is achieved through the utilization of patents and intellectual property laws, which serve to protect proprietary production methods (WIPO, 2021)

3.9.5 Environmental Factors

1. Sustainability: Emphasize sustainable production to reduce environmental impact. The enhancement of market appeal is achieved through the reduction of environmental impact, thereby promoting sustainability. The prioritization of sustainable production methods in Mycoprotein production is in accordance with consumer preferences and serves to mitigate the environmental consequences, as stated in the "Sustainability Assessment of Food and Agriculture Systems" report by the Food and Agriculture Organization in 2020.

2. Resource Availability: We need to ensure a stable supply of necessary resources. The maintenance of resource availability is crucial in order to mitigate potential disruptions in production, particularly in relation to the provision of agricultural substrates required for the production of Mycoprotein (FAO, 2021)

3. Eco-Friendly Packaging: Eco-conscious packaging aligns with sustainability goals. The utilization of environmentally friendly packaging materials and practices in the context of sustainability initiatives and in accordance with the preferences of environmentally conscious consumers has been found to be beneficial (Tukker et al., 2006).

4. Environmental Regulations: Staying compliant with environmental laws and regulations is vital for setting up a new mycoprotein production company. Adherence to environmental laws and regulations is of utmost importance in order to mitigate potential legal and reputational hazards arising from non-compliance with environmental standards (EPA, 2021).

3.9.6 Legal Factors

1. Intellectual Property Laws: We have to protect intellectual property related to Mycoprotein. The safeguarding of intellectual property pertaining to the production methods and strains of Mycoprotein is crucial for obtaining a competitive edge in the market, as stated by the World Intellectual Property Organization in their publication "Intellectual Property: A Power Tool for Economic Growth" (2021).

2. Labeling Regulations: Comply with labeling and nutritional information requirements. Adherence to labeling and nutritional information regulations must be maintained in order to establish transparency and foster consumer confidence (FDA, 2021)

3. Food Safety Standards: Meet stringent food safety standards to ensure product quality. Compliance to rigorous food safety standards, such as the Hazard Analysis and Critical Control Points (HACCP) system, is crucial in guaranteeing the quality and safety of food products (FDA, 2021, "Hazard Analysis and Critical Control Point (HACCP)").

4. Import/Export Laws: As a business, we need to understand and adhere to international trade laws. Comprehending import/export laws, encompassing customs regulations and tariffs, is essential for facilitating seamless import/export activities.

These points provide a more detailed understanding of the PESTEL factors influencing the establishment of a new Mycoprotein production company, covering various aspects of the external business environment.

3.10 Osterwalders Business Model

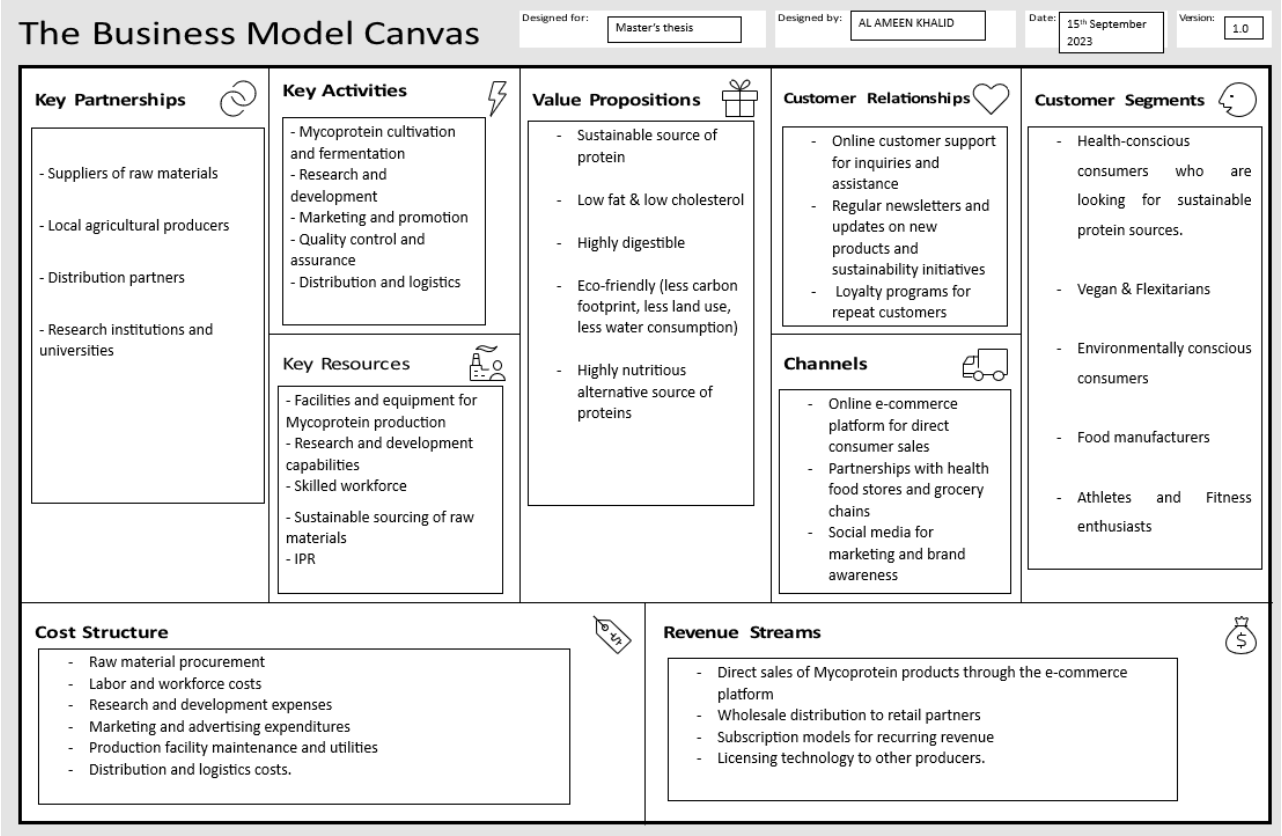

Figure 7: Osterwalders Business Model

1.Customer Segments:

The different groups of people or businesses that a business wants to serve are called customer segments. It's important to understand these groups because they affect how products and services are designed and tailored.

The customer segments include health-conscious consumers who are looking for sustainable protein sources, vegan & flexitarians, food producers, fitness enthusiasts and environmentally conscious people.

2.Value Proposition:

The Value Proposition describes the unique value that a business provides to each type of customer. It includes the features, benefits, and advantages of the product or service that meet the needs and requirements of the target customers. We can address the value proposition by

emphasizing the nutritional benefits, sustainability, and versatility of Mycoprotein products as well as its low impact on the environment.

3.Channels:

Channels define the various ways through which a business reaches and interacts with its customer segments to deliver its value proposition.

In this case, channels include online e-commerce platforms, partnerships with retail stores, and social media platforms for marketing and brand awareness.

4. Customer Relationships:

This is all about the different kinds of relationships a business builds and keeps with its customers. Getting new customers, retaining existing clients, and building relationships with them are all part of it. This includes online customer service, newsletters, loyalty programs, and educational projects about sustainability for Mycoprotein products.

5. Revenue Streams:

Revenue Streams show how the business model makes money. Basically, it shows how the company gets value from its customers. In our business to make mycoprotein, we could make money by selling directly through our e-commerce platform, distributing our products in bulk, offering subscription plans, and maybe even licensing our own fermentation technology.

6. Key Resources:

Key Resources refers to the critical assets and resources that the business needs to operate effectively. This includes tangible assets such as production facilities and equipment, as well as intangible assets like research and development capabilities, the expertise of a skilled workforce, IPR (Intellectual Property Rights) and sustainable sourcing of raw materials.

7. Key Activities:

Key Activities are the basic functions which is needed to execute in order to deliver the value proposition, reach customers, and maintaining the service delivery. These activities may include cultivation and fermentation, ongoing research and development for improvement of

the product, marketing and advertising campaigns, quality control, and efficient distribution of logistics for the production of mycoprotein.

8. Key Partnerships:

Key Partnerships refer to the strategic alliances and collaborations that improves the business's capacities and assets. Partnerships could be associations with suppliers of raw materials, locally based agricultural producers, distribution partners, and research institutions for continuous research and development cooperation.

9. Cost Structure:

The Cost Structure means a comprehensive breakdown of all costs and expenses related to the operation of the business. This includes procurement of raw materials, expenses related to labor and workforce, costs associated with research and development, expenditures on marketing and advertising, maintenance of production facilities, and distribution and logistics costs.

3.11 Choosing B2C (Business 2 Customer) Business Model for Generating Revenue

Logic for choosing B2C Mycoprotein Business in Norway-

Market Size and Consumer Awareness: Norway, similar to other developed nations, exhibits an expanding consumer market that demonstrates a keen interest in sustainable and health-conscious food products. Mycoprotein is in line with the growing consumer recognition of sustainable and plant-based protein sources.

Health and Sustainability Trends: Mycoprotein's nutritional benefits and sustainability profile make it attractive to health-conscious and environmentally-aware consumers, contributing to current health and sustainability trends. Faria et al. (2020) emphasize the nutritional and environmental benefits of using it as a protein source.

Consumer Education and Engagement: In a business-to-consumer (B2C) model, companies have the opportunity to engage directly with consumers, providing education on the benefits, nutritional value, and culinary versatility of Mycoprotein. Consumer engagement is essential in the food industry.

Brand Building and Loyalty: Brand building is crucial in the B2C market as it fosters consumer loyalty and trust. Giménez and Törnvall (2016) argue that supporting Mycoprotein's health and environmental benefits with scientific evidence can increase the credibility of a brand.

Customization and Diversification: B2C enables the customization of Mycoprotein products to align with consumer preferences, including flavors and formats. Jribi et al. (2021) highlight that it offers the opportunity to adapt product lines in response to evolving consumer preferences.

Direct Feedback and Improvement: B2C interactions provide direct consumer feedback, which can be useful for continuous product improvement and innovation

It's important to note that the choice between B2C and B2B should consider factors like market research, production capacity, distribution, and competition. Additionally, a hybrid model that combines elements of both B2C and B2B may also be an option, depending on the specific business context on follow-up market.

3.12 Setting up a Mycoprotein production company in Norway

This section presents a thorough examination of the viability and obstacles involved in the establishment of a Mycoprotein production facility in Norway. This aspect holds significant importance in comprehending the pragmatic implications of translating the theoretical capacity of Mycoprotein into a concrete manifestation.

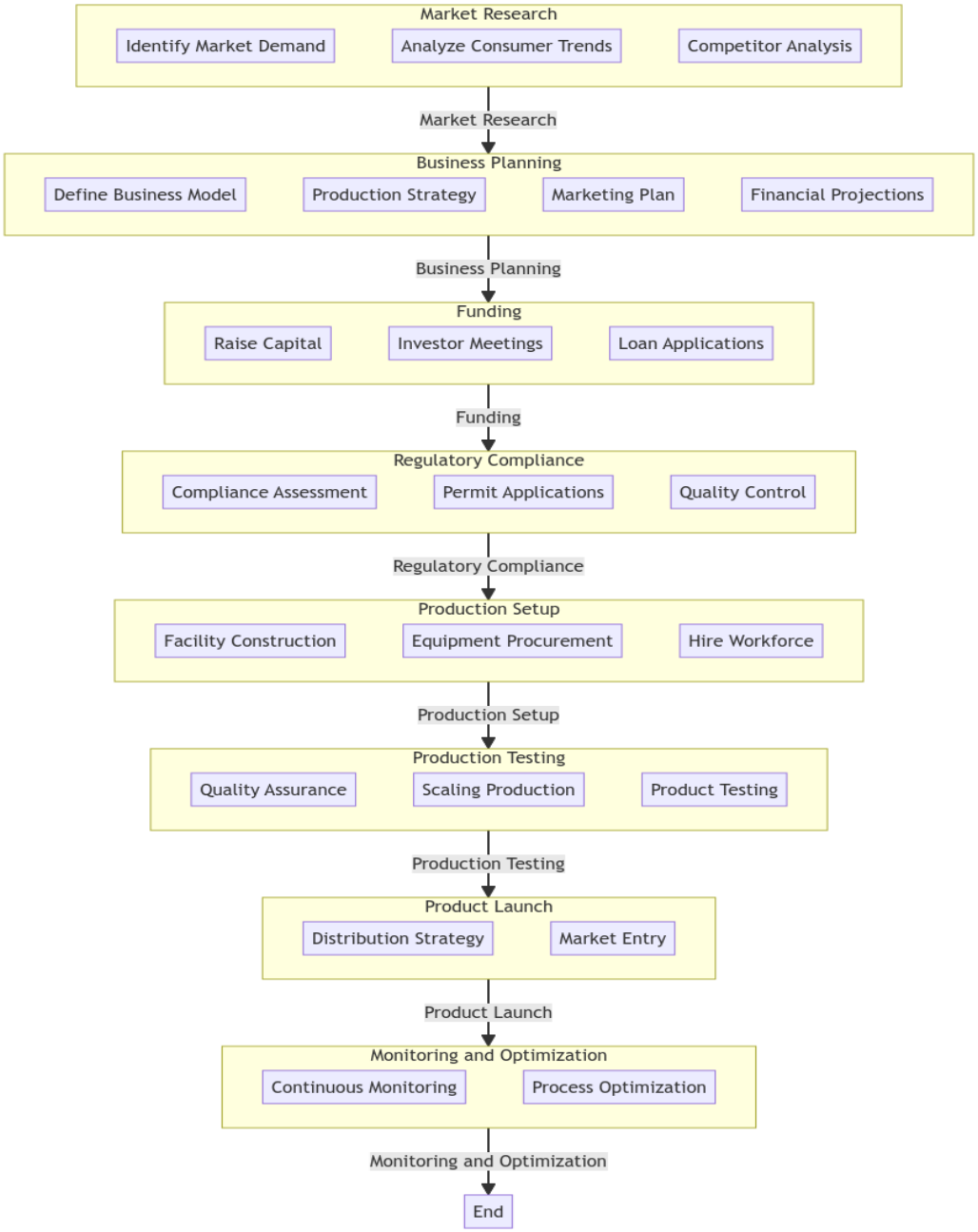

Figure 8: High-level specified pathway to set-up a Mycoprotein Production company in Norway

In this analysis, we explore various essential factors and aspects:

3.12.1 Evaluating the feasibility

1. Location Assessment: Our analysis focuses on the appropriateness of different sites in Norway for the purpose of Mycoprotein production. This evaluation takes into account key considerations, including the proximity to essential resources, the quality of transportation infrastructure, and the availability of skilled workforce.
2. Resource Availability: The sustainability of the production process can be ensured through a comprehensive analysis of resource availability, encompassing raw materials (substrates), water, and energy sources.

3.12.2 Regulatory and constitutional difficulties

1. Regulatory Framework: The regulatory framework associated with food production in Norway, which includes food safety standards, labelling obligations, and environmental regulations, is thoroughly examined in order to ascertain the requisite compliance measures and licensing procedures for the production of Mycoprotein.
2. Intellectual Property: An exploration of intellectual property rights and patents associated with Mycoprotein production processes and strains is undertaken to ensure legal protection and compliance.

3.12.3 Infrastructure and Resource Requirements

1. Facility Design: The design and layout of a Mycoprotein production facility, including considerations for production scalability, hygiene, and equipment selection.
2. Energy Efficiency: The significance of sustainability has led to an inquiry into energy-efficient technologies and renewable energy sources in order to mitigate the environmental impact of the facility.

3.12.4 Environmental Impact Assessment

The Environmental Impact Assessment (EIA) is a systematic process used to identify and evaluate the potential environmental effects of a proposed project, plan, or policy.

1. Environmental Footprint: The environmental footprint of Mycoprotein production is evaluated through an assessment that examines various aspects such as greenhouse gas emissions, water consumption, and waste generation. This evaluation is crucial in order to make sure that the production process is in line with sustainability objectives.
2. Mitigation Strategies: It examines various mitigation strategies aimed at reducing environmental impacts, including waste recycling, water treatment, and energy conservation measures.

These factors and aspects play a vital role in connecting the theoretical investigation of Mycoprotein's capabilities with the practical measures necessary for its commercialization. The text discusses the various complex challenges, regulatory factors, and infrastructure requirements involved in the establishment of a Mycoprotein production facility in Norway, with a particular focus on the significance of sustainability and adherence to regulations at every stage of the process.

This chapter establishes the necessary foundation for the future formulation of a feasible business plan, which aims to satisfy market demands while also upholding ethical, environmental, and legal principles, through an in-depth exploration of these various aspects.

3.13 Overall Discussion

The whole research paper explored Mycoprotein as a novel alternative protein source, comparing it to emerging alternatives such as insects and lab-grown meats, assessing the feasibility and challenges of establishing a Mycoprotein production factory in Norway, and developing a comprehensive business plan. In this section, we will summarize the findings, address the research objectives and questions, and draw significant conclusions.

The research investigation towards the potential advantages of Mycoprotein as a source of nutrition for both human consumption and animal feed has yielded encouraging findings.

Mycoprotein presents itself as a dietary alternative that is rich in protein, while simultaneously being low in fat and carbohydrates, thereby providing considerable nutritional value. In addition, the production process leads to minimal emissions of greenhouse gases, thereby demonstrating its alignment with sustainability objectives.

The comparative head-to-head analysis conducted in our study examined the attributes of Mycoprotein in relation to insects and lab-grown meats, resulting in the identification of several significant findings. Although insects possess high nutritional value and are considered environmentally sustainable, the acceptance of these organisms by consumers continues to present a considerable obstacle. Lab-grown meats encounter challenges in terms of scalability and cost, despite their nutritional similarity to conventional meat. Mycoprotein holds a distinctive position due to its ability to provide nutritional advantages and promote sustainability, while avoiding significant consumer aversions or production challenges.

Both opportunities and obstacles were uncovered during the feasibility study of setting up a Mycoprotein production facility in Norway. Because of its advanced infrastructure and highly trained labor force, Norway is in an advantageous position. Risks can be reduced and long-term sustainability can be ensured through measures such as adhering to regulatory and legal frameworks, securing resources, and conducting thorough environmental impact assessments.

The market analysis conducted revealed various segments for Mycoprotein, that includes health-conscious individuals who are looking for sustainable protein sources, vegetarians/vegans, and athletes who are actively seeking alternative sources of protein. The identification of the "beachhead market" holds significant importance, and our research findings suggest that health-conscious consumers present a highly profitable initial target segment owing to their heightened awareness of the nutritional advantages.

Developing a successful business plan for a Mycoprotein factory necessitates a multifaceted approach. Multiple business model options were explored. It was clear that the business-to-customer (B2C) business would help the newly found company to get a stronghold in the market to generate constant revenue. Financial projections revealed that careful cost management and efficient production processes are vital for profitability. Marketing and distribution strategies should capitalize on the product's sustainability aspect, appealing to health-conscious consumers who are looking for a sustainable eco-friendly protein source.

3.14 Suggestions for further research

This research paper offers a comprehensive framework for understanding the subject matter. However, additional research is required to further improve production methods, evaluate consumer attitudes, and monitor the ecological consequences of Mycoprotein production on a large scale. The rapid advancement of Mycoprotein's viability as an alternative protein source can be facilitated through collaborative endeavors involving academia, industry, and government entities.

4. Conclusion

In conclusion, this thesis explores the commercial potential of Mycoprotein as a sustainable protein alternative, with a specific emphasis on establishing a sustainable Mycoprotein production company in Norway.

The establishment of a Mycoprotein production company in Norway has significant potential for future sustainability. The resource efficiency, low greenhouse gas emissions, and efficient land use of mycoprotein are in line with global sustainability goals. The business model has the potential to influence dietary choices towards more environmentally friendly options by providing consumers with a sustainable protein source.

However, there are challenges that need to be addressed in the future, including competition from other alternative proteins, vulnerabilities in the supply chain, and consumer skepticism. To effectively tackle these challenges, it is crucial to engage in continuous research, foster innovation, collaborate with stakeholders, and prioritize transparency and safety.

In a nutshell, this thesis highlights the prospective of Mycoprotein as a sustainable protein alternative and offers a comprehensive guide for establishing a production company in Norway. The integration of scientific knowledge, technological advancements, and business acumen has the potential to lead to a sustainable and protein-secure future. The integration of mycoprotein into the Norwegian market has the potential to stimulate economic growth and promote environmental sustainability. Mycoprotein is gaining prominence as a potential solution to the increasing global demand for sustainable protein sources, and it is expected to have a significant impact on the future of food production.

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