Final Report

Methods to utilise Fish Waste

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Novia University of Applied Sciences

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Abstract

This project, integrated within the European Project Semester (EPS) program, is led by a team of four international students, each bringing their unique perspective. We consist of a French, Belgian, Spanish, and Ghanaian student. Together, we will seek to identify and develop innovative methods to stabilize and reuse fish waste generated by local fishermen's activities. The cultural diversity and varied professional experiences of the team members will significantly enrich the research and development process, fostering a creative and inclusive approach. In collaboration with local fishermen, our project supervisor, and various external individuals whom we will be able to ask many questions, we will conduct research to evaluate existing techniques and explore new approaches to reduce waste and maximize the value of fish waste. During the 6 months of our project, we will focus on testing three selected methods, for which various p rototypes will be developed. However, the project will continue for two years, allowing for a more thorough evaluation and refinement of the methods. The outcomes of this study will contribute to improving the economic and environmental efficiency of fish waste management, providing local fishermen with new revenue opportunities through waste valorisation. Additionally, this project may serve as a model for other regions in Finland and potentially be extended to other sectors, offering broader economic and environmental benefits to the fishing sector. The diversity of our team will enhance our ability to innovate and find relevant solutions tailored to the varied needs of local communities.

Language: English
Key Words: Fish Waste, Stabilization, Investigation, Research and Innovation

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1.Team members

Our team consists of 4 engineers from various backgrounds and nationalities: Nora, Quentin, Fayaad and Timothy. We have been tasked with a project aimed at stabilizing fish waste so that it can be repurposed for other uses in the near future. Each of us brings different skills and experiences to the project, contributing strengths and eager to learn from one another. It is a challenge for us, but one that we will overcome.

1.1 Nora Brugada

I am from Girona, a small city. I am an Industrial designer and product developer engineering student at UPC University of Vilanova I la Geltrú. Currently, I am doing the EPS Project at Novia University of Applied Sciences, in Finland.

Figure 1:Nora

I am a perfectionist and committed girl. Since I was a child, I have been interested in robotics, innovative technologies and entrepreneurship projects. I study engineering because I am willing to learn how to use new tools to design and create innovative, sustainable and useful products. Moreover, I play water polo in Catalan league, but I also enjoy other sports like tennis, surf, ski and open water swimming, which I practise often.

1.2 Timothy Mous

I am Timothy Mous, I am from Belgium and live in a city called Antwerp. Currently I study Energy management at Artesis Plantijn (AP) also in Antwerp. Right now, I am doing the EPS project at Novia University of Applied Sciences in Finland.

A bit about myself, when I graduated from high school, I did not know what I wanted to do. After a lot of thinking I chose to go study some more and started my first year of Electromechanics, but then corona hit us, and I dropped out of school and started working. After one year of working as a maintenance mechanic, I realised this was not what I wanted to, so I went back to school. Then after a long search I found out there was a study I could follow that is all about sustainability called energy management and from that moment I looked no further and started my study.

Figure 2:Timothy

What I can say about myself is that I am a person that loves to learn new things and ways of thinking, likes working for projects that are for a more sustainable future and loves working in a team to bring the best possible outcome forward.

1.3 Fayaad Babs-Khalid

I am Fayaad, currently pursuing Agricultural Engineering at the University for Development Studies. Despite my field of study, my ultimate aspiration lies in entrepreneurship.

I hold immense respect for my academic path but envision myself as a future businessperson. My decision to study Agricultural Engineering stems from a deep desire to enhance my father's Cashew farm.

I consider myself a versatile individual, eager to learn and explore various domains. While I enjoy watching football, basketball is my preferred sport for physical activity.

Figure 3:Fayaad

1.4 Quentin Rames

I am Quentin Rames and I come from France. I am currently a student in the fourth year of formation at the National School of Engineer of Tarbes where I study general things like mechanical engineering, industrial engineering and also the field of the construction. During our fourth year of formation, we have to do a mobility on another country during one semester (4 months). It is for that, I decided to do the European Project Semester (EPS) at Novia University of Applied Sciences at Vaasa in Finland.

I study very general subjects at my school like mechanical engineering, industrial engineering, electronics, and construction, but my career plan is to work in the construction field as a civil engineer.

To finish about myself, I am a workaholic, so if I am passionate about a project, I do not count the hours I spend on it. Moreover, I am very curious and like to learn new things, in any field. Finally, I am a very fussy person and I like a job well done.

Figure 4:Quentin

2. Introduction of the project

The project we have been tasked with is called fish waste. The purpose of the project is to find the best way to stabilise fish waste after the fishermen have taken everything from the fish that they need. The project has been created because at this time over 60% of the fish is waste, this is a large problem for the fish industry. So only 40% gets used right now, the fish is mostly used for food purposes. Preservation and reutilization of fish waste present significant ecological and economic challenges in the fishing industry. With this in mind, this report presents an innovative research endeavour focused on exploring opportunities for valorising fish waste in the Ostrobothnia region. The primary objective is to increase the income of local fishermen without requiring significant investments, while also contributing to marine ecosystem preservation.

We begin with an in-depth analysis of the characteristics of Ostrobothnia fish species and various techniques for preserving and reusing fish waste. This study will help determine the most suitable approaches considering the specific needs and constraints of the region's fishermen.

Subsequently, we will select three methods from those identified during the research, deemed the most promising and well-suited to local conditions. These methods will undergo on-site experimentation to assess their technical feasibility, economic viability, and acceptance by fishermen.

Finally, we will present detailed results from the experimentation of the three selected methods. We will compare their respective performances in terms of costs, yields, and environmental impact, highlighting their advantages and drawbacks. In conclusion, we will provide recommendations to facilitate the adoption and widespread implementation of the best practices for valorising fish waste in the Ostrobothnia region.

3. Objectives of the project

- Learn about fish waste – composition and behaviour.
- Research all possible stabilization methods of fish waste.
- Select 3 methods for the stabilization of fish waste.
- Obtain valuable fish products using various methods of stabilization.
- Create and build a lab-bench test for fermentation method. It must work autonomously and with a sensor system to check that the process is correct.
- Collect two months' worth of sensor data and analyse it.
- Research different product possibilities for a future team.
- Research protein extraction methods for future team.

4. Research

Here we are going more in depth about the research we did beforehand about the project, mentioned before it is very important to have a good understanding of how and what you want to create with the following project.

4.1. Main problem of fish waste in Ostrobothnia

In Ostrobothnia, fishing is a diverse activity that spans the coastline, rivers, and lakes. From a national standpoint, Ostrobothnia boasts a significant fishing industry, hosting just over a quarter of the country's fishermen. These fishermen contribute substantially to the nation's catch, accounting for nearly half of the common white fish, a third of perch, and over a quarter of herring catches in Finland. Fishing in Ostrobothnia involves boats under 12 meters, operating near fishing ports or smaller harbours. Utilizing standing or anchored gear, such as passive fishing methods. Commercially, the region's fishing sector focuses on various species including Baltic herring, sprat, common white fish, perch, and salmon. Additionally, burbot, pike, smelt, trout, bream, roach, and other cyprinids play significant roles in Ostrobothnia's commercial fisheries. (Fish Point, 2024)

However, it is crucial to note that only 30-40% of the fish by weight is converted into meat suitable for human consumption. With the fishing sector of Ostrobothnia producing approximately 16.5 thousand tons of fish annually, this means that around 10 thousand tons of fish waste are generated each year.

This significant amount of fish waste underscores the importance of implementing effective waste management strategies to mitigate environmental impacts and promote sustainability in the region's fishing industry. (Ehrs, 2024, page 3)

4.2. Types of fish in Ostrobothnia

4.2.1 Information about fish

In Ostrobothnia, a region in Finland known for its rich aquatic resources, various types of fish thrive in its lakes, rivers, and coastal waters. Among the most common species found in Ostrobothnia are freshwater fish such as perch, pike, and zander. These species inhabit the numerous lakes and rivers scattered throughout the region, providing ample opportunities for both recreational fishing and commercial harvesting.

Additionally, Ostrobothnia's coastal waters are home to a diverse array of marine species, including Baltic herring, salmon, and whitefish. These species support vibrant fishing industries along the coastline, with traditional fishing methods often passed down through generations.

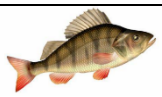
We had the chance to speak with Anita Storm, who gave us more information on the fish most present in the region, as well as the main local fishermen, where we could collect fish waste of different species of fish.

Here is what we can have as species of fish caught in Ostrobothnia:

Swedish name	English name	Best Time of the year to catch
SIK	White fish	March-May
LAX	Salmon	May-September
STRÖMMING	Herring	September-February
ABBORE	Perch	March-November
GÄDDA	Pike	March-November
LAKE	Burbot	December-february
BRAXEN	Bream	March-November
MÖRT	Roach	March-November
NORS	Smelt	Always

4.2.2 What type of fish we use for our experimentation

For our experiments, Mikael went several times to collect buckets of fish waste from fishermen near Vaasa. We were therefore able to experiment with diverse types of fish which we have listed below specifying which parts of the fish we had each time:

	Zander / Pike Perch	Salmon	Perch	Pike	White fish
Type of fish					
Experimentation uses	Scale Skin Fishbone Head	Head Leftover fillets Fishbone	Head Fishbone Scale Skin	Scales Skin Fishbone Head	Head

Thanks to this diversity of fish, we were able to find everything we needed for our experiments because we had fish that were very different in size but also fish that feed in different ways, which therefore allowed us to exploit different things. Thanks to this diversity of fish, we were able to find everything we needed for our experiments because we had fish that were very different in size but also fish that fed in different ways. For example, we have salmon, which is a very large fish, with very large fish bones. We also had zander, a carnivorous fish with lots of large scales that are easy to collect. We also had perch and pike, predators very common in Finland, having a fairly similar diet but remaining 2 fish with different morphology and properties. We also had white fish, which had a completely different diet from predatory fish. This diversity therefore allowed us to experiment with everything we wanted to experience during our project.

Figure 5:Fish waste diversity

4.3. Fish Waste properties

Next, we are going to talk about the properties of fish waste. This is an important topic and should be researched good so there are no questions surrounding this topic. In the next page you will see what we can obtain from the fish waste that we got and what we tried to obtain from it.

4.3.1 Skin and scales

The skin and scales of fish possess beneficial properties attributed to various components. Collagen, a key fibrous protein, serves as the primary constituent of intercellular layers and connective tissues. Gelatin, a water-soluble colloidal protein, is derived through controlled hydrolysis of collagen. Furthermore, bioactive peptides found within these structures exhibit antioxidant and anti-inflammatory properties, potentially advantageous for cardiovascular, digestive, and metabolic health. Keratin, another pertinent component, provides mechanical strength and protection, proving valuable in biomedical and cosmetic applications. Lastly, proteins and amino acids present are essential for the growth, repair, and maintenance of muscle tissues, organs, and bodily systems, with potential extraction and processing for various applications including cosmetic formulations and biomedical materials.

4.3.2 Skeleton of the fish

The skeleton of the fish, beyond its structural role, encompasses a wealth of beneficial properties. **Calcium and other minerals** not only contribute to bone strength and dental health but also play essential roles in maintaining muscle contraction and nerve transmission. **Collagen**, being the predominant protein in the skeleton, not only provides structural support but also facilitates wound healing and tissue regeneration. Additionally, the skeleton serves as a reservoir for various bioactive compounds, including peptides with antimicrobial and

anti-inflammatory properties, thereby contributing to the fish's immune defence system. (Tung et al., 2017)

4.3.3 Liver

The liver of the fish is replete with beneficial components, offering a spectrum of advantages for human health. Omega-3 fatty acids, abundantly found in the liver, are renowned for their contributions to cardiovascular health, brain function, eye health, and inflammation reduction within the body. Additionally, the liver serves as a rich source of essential vitamins, including B vitamins, vitamin D, vitamin E, and vitamin A. These vitamins play pivotal roles in metabolism regulation, bolstering immunity, maintaining optimal vision, and promoting skin health. With such a diverse array of nutrients, the liver stands as a potent source of wellness-promoting compounds, encompassing benefits across various bodily systems. Furthermore, the liver's role as a hub for nutrient storage and metabolism underscores its significance in supporting overall health and vitality. (Pérez Gálvez & Bergé, 2013)

4.4. Stabilization methods

Fish is an extremely perishable food item and requires preservation for future use. Several preservation methods are followed worldwide for preserving fish. The aim of all these methods is extend the shelf life of fish so that it can be properly used in the future. (Galib, S. 2011)

Stabilizing fish waste is crucial for maximizing its value and minimizing environmental impact. Various methods are employed to preserve its nutritional content and functional properties. These stabilization techniques do not only prolong the shelf life of fish waste but also enable its versatile utilization in various industries, including food, cosmetics, and agriculture.

Let's delve deeper into these methods and their applications.

4.4.1 Drying

Drying is the oldest known method of preserving perishable food items including fish. This method is also considered as the least expensive method of preservation.

Two common terms used in fish drying are "natural drying" and "artificial drying." These two are both the methods of preserving fish, almost similar but with little differences. Drying involves the removal of water content from the fish’s body. Natural drying, which includes sun drying and wind drying, relies on sunlight and natural air circulation to eliminate moisture. It is applicable to various materials such as fruits, vegetables, herbs, and fish, particularly in regions with consistent sunshine and low humidity levels. However, it is slow, dependent on weather conditions, and vulnerable to insect infestation and contamination.

On the other hand, artificial drying methods, such as oven drying or freeze drying, offer efficient ways to remove moisture from materials. Oven drying, almost same a sun drying, except that this process is practiced under controlled operational parameters, utilizes heated

air within an oven to dehydrate substances, providing quicker drying times and better control over temperature and humidity than natural methods. However, it can be energy-intensive and may lead to uneven drying or overheating without careful monitoring. On the other hand, freeze drying is a sophisticated technique that involves freezing the material and then sublimating the ice directly into vapor under low pressure. This method preserves the material's structure, flavour, and nutrients exceptionally well, but it requires specialized equipment and is often costlier than other drying methods. (Galib, S., 2011)

	Pros	**Cons**
Natural drying	Simple and low-cost Sustainable Preserves certain properties	Slow drying times Weather dependence Risk of spoilage Limited application
Artificial drying	Faster drying times Controlled environment Wider application Improved product quality	Energy consumption Higher cost Potential for uneven drying Loss of certain properties

4.4.2 Smoking

Smoking is a method for preserving fishes that, after previous salting, are processed with organic components obtained from smoke. Smoke contains volatile aromatic substances that give specific features to fish flesh and have bactericidal effects. Smoked fish is a flavourful and nutritious product, ready for use with or without further cooking or processing. Besides useful compounds, smoke contains harmful substances that have carcinogenic properties. (K.Belichovska, D.Belichovska, Z.Pejkovski, 2019) (Rooftopgardener, 2024).

	Pros	**Cons**
Smoking	Enhances flavour Extends shelf life to some extent	Health risks Uneven preservation Loss of nutrients Environmental impact

4.4.3 Salting

Salting is a fish-preservation method, and it is used in many countries of the world. It is also used in the preprocessing of fish before processing technologies such as smoking, drying, and canning are employed. The main function of salting is the removal of some of the water from fish flesh and its partial replacement by salt. Salting reduces the water activity of fish; hence, microbial and enzymatic activities are also reduced. The ripening of salted fish is the biochemical process that causes the change in chemical and physicochemical characteristics of the fish tissues. The end of the salting process is the moment when all the fish has reached

the required salinity and acquired the appropriate taste. (H.Turan, Erkoyuncu, I.Erkoyuncu, 2012)

	Pros	Cons
Salting	Extended Shelf Life Preservation of Nutrients Simplicity Distinctive Flavour Cheap Facilitated Transportation	High sodium content Texture Alteration Need for rinsing before cooking Risk of Over-Salting Hygiene Control Needed

4.4.4 Pickling

Pickling, also known as canning or lacto-fermentation, is an ancient method of food preservation that dates back several centuries. There are different pickling techniques, but the most common method involves immersing food in an acidic or salty liquid solution, usually called a brine.

Acidic brines are made from either salted water, sugar water, lemon juice or vinegar. Each of these substances is poured over vegetables, fruit, meat or fish, which are then left in a sealed jar at room temperature for a period of time.

During this process, natural bacteria present on the food or deliberately added to the brine come into play. These bacteria convert the sugars in the food into lactic acid, creating an acidic environment that preserves the food and develops complex flavours. (Asia Society, 2024)

	Pros	Cons
Pickling	Distinctive and customized flavour Simple preparation Preservation of nutrients No need for daily monitoring.	Texture changes High Sodium Content Risk of Over-Pickling Hygiene Concerns Not available with all species of fish

4.4.5 Freezing

Conventional freezing is a method of preserving food by reducing its temperature to below freezing point, typically between -18°C to -30°C (0°F to -22°F), using a freezer or similar equipment. This process slows down or halts microbial growth, enzymatic activity, and chemical reactions, thereby extending the shelf life of the food.

It is of utmost importance to handle the fish with care immediately after capture, as this initial treatment sets the groundwork for maintaining the fish's integrity during freezing.

Following that, prompt removal of guts and thorough cleaning of the fish are essential. This step eliminates potential sources of contamination and spoilage, contributing significantly to the overall quality of the frozen fish. (Biavatec, 2024)

	Pros	**Cons**
Freezing	Simple preparation Preservation of Nutritional Value Maintains quality of the fish Extended Shelf Life	Freezers require Formation of ice crystals

4.4.6 Vacuum Packaging

Vacuum packaging is a method of packaging food products by removing air from the package before sealing it. This process involves placing the food in a vacuum-sealed bag or container and using a vacuum sealer to extract air, creating a vacuum environment inside the package. The package is then heat-sealed to maintain the vacuum and preserve the food. (R.Perdue, 2009)

	Pros	**Cons**
Vacuum Packaging	Extended Shelf Life Preservation of freshness, flavour, nutrients, etc. Prevention of freezer burn Protection against contamination	Cost of the equipment Packaging material waste Risk of botulism

4.4.7 Canning

Canning is a meticulous preservation process for fish, starting with thorough cleaning and expert splitting. The fish is then treated with carefully crafted brine solutions to preserve and enhance its flavour. After brining, the fish is rinsed to remove excess salt and impurities. Next, it undergoes drying to eliminate moisture, crucial for preventing bacterial growth. The prepared fish is packed into cans designed to create a sealed, protective environment, safeguarding it from contaminants and air. Heat treatment eradicates remaining harmful microorganisms and extends shelf life. Finally, the cans are sealed under pressure to maintain sterility. This process ensures that canned fish remains safe, flavourful, and ready for consumption over an extended period, making it a convenient and reliable food choice. (Bivatec,2024)

	Pros	**Cons**
Canning	Extended Shelf Life Convenience to store, transport and use Preservation of Nutritional Value Safety	Loss of sensory quality Cost and require specialized equipment Environmental impacted during de production

4.4.8 Fermentation

Fermentation preservation is an ancient and proven method for extending the shelf life of foods. It relies on the fundamental principle of beneficial microorganisms, such as lactic acid bacteria and yeasts, transforming food components to make them less conducive to the growth of undesirable microorganisms.

This biochemical process involves the metabolism of carbohydrates present in foods by microorganisms to produce various compounds such as organic acids, alcohol, and carbon dioxide. These chemical changes often result in a modification of the food's pH, creating an inhospitable environment for pathogenic bacteria and molds, thus contributing to its preservation.

There are three main types of fermentation processes utilized for extracting substances from fish. The first type is **lactic acid** fermentation, where microorganisms, such as certain lactic acid bacteria convert the sugars present in fish waste into lactic acid. This process is occurring in an anaerobic environment, facilitates the conversion of sugars in fish waste into lactic acid by specific lactic acid bacteria. This helps reduce the pH and acts as a preservative, inhibiting the growth of unwanted microorganisms. Additionally, lactic fermentation can improve the texture and flavour of the final product.

The second type is **acetic acid** fermentation, where acetic acid bacteria convert the organic compounds present in fish waste into acetic acid. This method can occur under both aerobic and anaerobic conditions, although it generally proceeds more efficiently in aerobic environments. This process can be used to produce fish vinegar, which may have culinary and preservation applications.

The third type is **alcoholic fermentation**, is a biological process carried out by yeast or some types of bacteria in the absence of oxygen. During this process, sugars such as glucose are broken down by the microorganisms into ethanol (alcohol) and carbon dioxide.

Finally, we have **mixed fermentation**, where multiple types of microorganisms can be used in combination to ferment fish waste. For example, a combination of lactic acid bacteria and acetic acid bacteria can be used to produce a variety of fermented products, such as fermented fish paste or fermented fish sauce.

Fermentation preservation is used worldwide to preserve a wide variety of foods, including vegetables, fruits, grains, dairy products, meat, and fish. In addition to extending the shelf life of foods, fermentation can also enhance their flavour, texture, and nutritional value, making it a valuable and versatile method in both home cooking and food production.

The optimal fermentation conditions vary depending on the microorganisms involved and the type of food being fermented. Factors such as temperature, pH, salt and sugar concentration,

and the presence or absence of oxygen can all influence the fermentation process. (M.Quijal, F. J., F.Remize, G.Meca, E.Ferrer, M.Ruiz, F.Barba, 2020)

	Pros	Cons
Fermentation	Extended Shelf Life Convenience to store, transport and use Preservation of Nutritional Value Safety	Loss of sensory quality Cost and require specialized equipment Environmental impacted during de production Risk of botulism

4.4.9 Bio preservation

Bio-preservation on fish involves using natural or controlled microbiota, such as lactic acid bacteria (LAB), and antimicrobials to extend the shelf life of the fish. This technique helps control spoilage and inhibits the growth of harmful pathogens, thus maintaining the freshness and quality of the fish for a longer period. (Veer Singh,2018)

	Pros	Cons
Bio preservation	No chemical preservatives Maintained sensory attributes Potential health benefits Versatility applications	Complex process Live microorganisms pose contamination risk Potential for allergenic reactions

4.4.10 Pasteurization

Fish pasteurization involves applying heat to fish products to kill pathogens and extend shelf life. The process typically involves heating the fish to a temperature below the boiling point of water, usually around 60-85°C, for a specific period of time. This helps inactivating harmful microorganisms while preserving the quality of the fish. However, like with other forms of pasteurization, it is important to note that bacterial spores are not destroyed, so pasteurized fish products still require proper handling and storage to prevent spoilage. (A.Helmenstine, s. f.)

	Pros	Cons
Pasteurization	Quality retention of texture, flavour and nutritional values Less aggressive heat treatment	Selective microbial reduction Sensitivity to overcooking Potential for recontamination after the treatment Complexity process

4.4.11 Irradiation

Irradiation is non-thermal food preservation technique which is used to extend and enhance the shelf life of fresh or processed foods. Food irradiation is an energy-efficient, non-chemical method of food processing that can help reduce those huge losses occurring due to spoilage or contamination by harmful bacteria and other parasitic life forms. It involves exposure of foods to ionizing radiations either prepackaged or in bulk to reduce the risk of foodborne illness, delaying or eliminating sprouting or ripening. Gamma rays, electron beams, and x-rays are used for irradiation of foods. (S.Ashraf, 2019)

	Pros	**Cons**
Irradiation	Quality preservation of fish qualities Reduced dependency on chemicals Controlled process	Perception and acceptance of the method Cost of equipment Regulatory compliance Energy consumption Limited applications Microorganisms could develop resistance to irradiation over time

4.5. Three chosen methods

Once we had listed most stabilization methods we could use in our project, we had to choose 3 methods to test during our project period. To choose these 3 methods we had to pay attention to several factors. The first thing to consider was the feasibility of the methods. We therefore set aside the bio-preservation method, as we lack knowledge in this field. Another important aspect was to put ourselves in the fishermen's shoes. We are doing this research for them, so the methods we test have to be adapted to their needs, but above all to their budget and their trade. The idea was to eliminate methods that would be too costly, as most of a fisherman's profit comes from the direct sale of fresh fish, not from the sale of fish that hasn't been fished recently. A fisherman is unlikely to want to spend large sums of money on a product that would just preserve his stocks a little longer, as they already have cheap solutions that meet this need. So, we turned to the other part of our project, the reuse of fish waste. With this in mind, we focused on methods that would enable us to obtain new products that could then be sold, bringing money to the fishermen. We will show you the reuse possibilities we found next.

This allowed us to sort through the available preservation methods and choose our 3 methods.

4.5.1 Fermentation

The first method we chose was fermentation. This method was a bit of a no-brainer for us, as it seems to meet the needs of fishermen very well and is quite simple to carry out. It is also important to note that we already had some ideas of what we could build to use this method as a preservation method, and we also had an interesting video given to us by our teacher.

So, this is going to be the main method we are going to test, and the one we are going to spend the most time and budget on, in order to get the biggest, most practical prototype possible. We are going to focus on this method because, as well as being an effective preservation method, it allows us to obtain an already well-known product, 'garum', a fermented fish-based Roman sauce, which we will describe in more detail in the next section.

Garum is a product that sells very well, allowing fishermen to make money from their fish waste. So, in theory, this method is perfect.

4.5.2 Freezing

The second method we have chosen is freezing. This method seems very simple and widely used, but we think we can make it even more advantageous, especially because it preserves not only nutritional values (the better fish, 2020), but also other elements such as collagen, which can be found in skin, bones, muscle tissue, fins or tails, and which can be used for other purposes that we will introduce later. Freezing therefore offers great possibilities and is perfectly suited to the need for preservation. However, we need to test not only how long it really works, but above all its ability to preserve the interesting components of fish waste so that they can be reused and turned into saleable products.

4.5.3 Pickling

The third and final method we are going to test is pickling, which we have chosen to do last, mainly because the process is simple and can be left for a long time.

This method is therefore very easy to implement. We will probably have to think about how to use it for large-scale production to better meet the needs of fishermen. But the possibilities are many. The first advantage of this method is that you can obtain several different flavours and thus vary the taste, which can be very useful if you want to produce by-products that are eaten as fish oil, for example. What is more, this method does not cost much, and the consumables required are very inexpensive. However, we still have a lot to test with this method, such as the duration of the preservation effect, as this will undoubtedly vary greatly depending on the additives we use.

4.6. Fish Waste possible products

To produce as many solutions as possible, we started by brainstorming diverse ways of reusing fish parts.

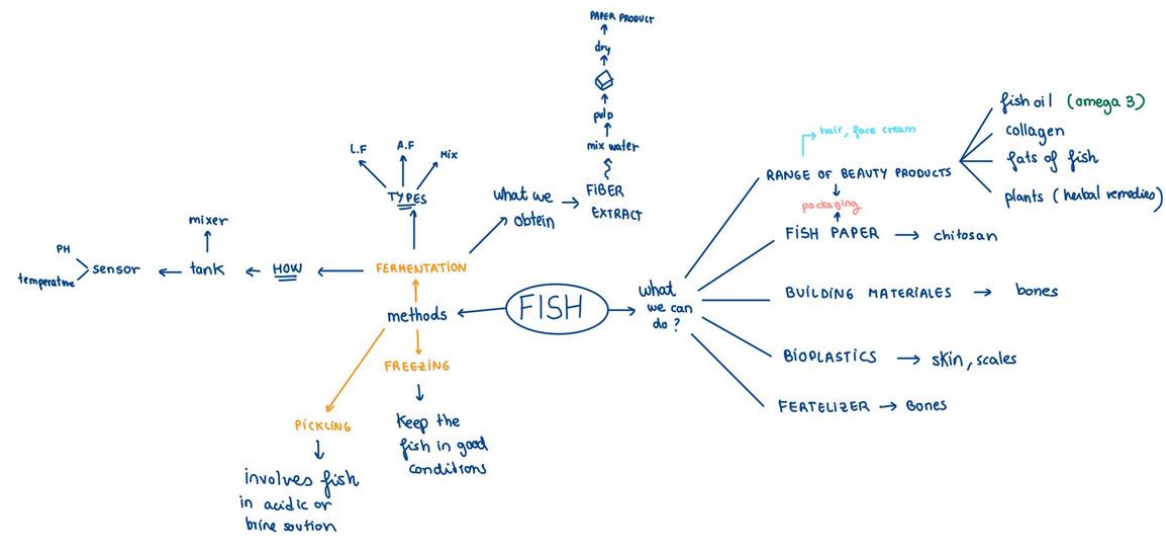


Figure 6:Braistorming of possible reusing of fish waste

4.6.1 Bioplastic

One option is to try a bioplastic material. Marinatex is a recent innovation in sustainable materials, developed as an alternative to traditional plastic. It is made from organic materials such as fish waste, specifically fish skin, and is biodegradable and compostable. Marinatex offers a promising solution to the environmental problems associated with traditional plastics, providing a renewable and environmentally friendly option for various applications, from packaging to textiles. (Arroyo, P., et al. 2016)

4.6.2 Fish paper

Another product craft option is the production of paper from fish, which is an innovative and sustainable solution to reduce waste and fully utilise marine resources. This process uses fish fibres, such as scales and skins, to create biodegradable and environmentally friendly paper, offering an environmentally conscious alternative to traditional methods of papermaking based on plant fibres.

However, you need to be careful about the cost of manufacturing the latter, because if the price is higher than that of conventional paper, customers will probably prefer to buy conventional paper.

4.6.3 Building materials

We could also reuse fish bones by putting them in concrete. If the bones are not altered by the concrete and its components, using the bones as fibre could make it possible to obtain a "cleaner" fibrous concrete. Fibrous concrete is very often used for its interesting characteristics. Fibres in concrete play a crucial role in improving the properties of concrete, with the focus on reducing the risk of cracking due to plastic shrinkage of concrete at a young age. They promote better cohesion of fresh concrete, reduce bleeding and segregation, reduce spalling, and improve resistance to impact, abrasion and fire.

These days, the construction sector is one of the most polluting, and more and more standards are being introduced to reduce the sector's carbon footprint. In France, for example, the RE2020 standard was introduced at the beginning of January 2022, requiring a lifecycle analysis of buildings, considering all greenhouse gas emissions, from construction to demolition. As a result, we need to think more carefully about the way we construct a building and, above all, the materials we use, because everything is considered. This carbon footprint takes absolutely everything into account, including transport by lorry, the manufacture of the materials used, and whether the materials used can be recycled.

If we take these standards into account, fibrous concrete made from natural materials or waste that we reuse will be much more interesting than fibrous concrete made from synthetic micro-fibres, the manufacture of which will emit much more CO2. Even if the price is a little higher, concrete companies will prefer to use concrete with a lower carbon footprint than conventional fibre concrete.

4.6.4 Cosmetic products

We are thinking of creating a range of beauty products using the potential benefits of fish waste. Fish waste could be rich in collagen and fats, which has many benefits for skin and hair care. Collagen extracted from fish waste deeply moisturises and revitalises skin and hair, reducing dryness and increasing elasticity.

In skincare formulations, it serves as a thickening agent for products with low pH levels and enhances stability as an emulsifying agent, particularly in moisturizers and creams.

For soap production, fish collagen adds nourishing properties, contributing to overall skin health in both solid and liquid forms. (Pérez Gálvez & Bergé, 2013)

4.6.5 Fertilizers for agriculture

Fish waste can be a very good way of obtaining fertilizer for farmers and private individuals alike. For example, during the pickling process, a nutrient-rich liquid is produced. This liquid can be diluted to create a concentrated liquid fertilizer, thus providing a dual valorization of fish waste. Additionally, the remaining solid waste can be used to produce solid organic fertilizers.

These natural fertilizers are rich in essential nutrients and promote healthy plant growth. An intelligent recycling solution for sustainable agriculture. (Sangodoyin Olakunle. M et al., 2021)

4.6.6 Biofuel

Fish waste, rich in oils, can be a valuable source for biofuel production. After extracting the oils, they undergo transformation processes such as transesterification to produce biodiesel. This biodiesel can serve as a more sustainable alternative to conventional fuels, thereby reducing carbon footprint while valorizing waste from the fishing industry. Moreover, this process contributes to transitioning towards a more circular economy and reducing environmental waste. (L. Fiori et al., 2017)

5. Experimentation and manufacturing

5.1 Fermentation stand

5.1.1 Execution plan

The project will aim to automate the process primarily to obtain Garum. As detailed in the previous section, this entails fermenting fish waste. Utilizing a YouTube video that explained the Garum production process, we have compiled a summary to outline all necessary requirements for the procedure, including the equipment.

Requirements of the process:

- The fish-to-salt ratio should be 8:1. In other words, for every 8 kilograms of fish waste, 1 kilogram of salt is needed. 12,5% of salinity.
- Fermentation tank for the process.
- Equipment for mixing fish waste and fermenting microorganisms uniformly, thus promoting microbial activity and process homogeneity.
- Devices for monitoring and adjusting the temperature and pH of the fermentation medium, which is crucial for maintaining optimal conditions for microbial growth.
- Filtration equipment to separate the fermented final products from solid, liquid, or gas waste.
- Devices for controlling parameters such as temperature, pH, pressure, flow, and nutrient concentration during the fermentation process.
- Gaseous ventilation during fermentation to mitigate odors.

5.1.2 Steps for fermentation process

The steps we will follow for the fermentation process are as follows, derived from the Garum production video on YouTube.

We can divide the stages into 4 phases:

1) Preparation: For this step, the fish should be portioned into medium-sized pieces. It is important to do not clean the fish. Maintaining the fish-to-salt ratio, begin by layering the fish at the base of a container, alternating with layers of salt. The components need to be thoroughly mixed.
2) Fermentation parameters: Once the mixture is prepared, we will need to wait for 2-4 months for the fish to ferment completely. During this time, a constant temperature between 25-30°C will be necessary, and the substrate should be mixed twice a day.
3) Straining and storage: Once step 2 is completed, the product will need to be filtered to separate the liquid (garum) from the remains that have not decomposed.

With our design, we will optimize this process to make it more autonomous, so that it won't be necessary to examine the process daily.

5.1.3 Design

For the fermentation part, we decided to start with a plastic tank in order to facilitate testing of the process and detect what adjustment may be necessary. Once we have fully understood the fermentation process and its particularities, we will build a stainless-steel prototype, which will be closer to the final product.

Two prototypes for the fermentation tank will be developed. The initial prototype will be constructed using a plastic tank, followed by a subsequent iteration utilizing a stainless-steel tank.

To commence the design process, a brainstorming session was conducted to identify the necessary components required for creating the fermentation tank. Consequently, the ideas were documented, leading to the generation of different designs:

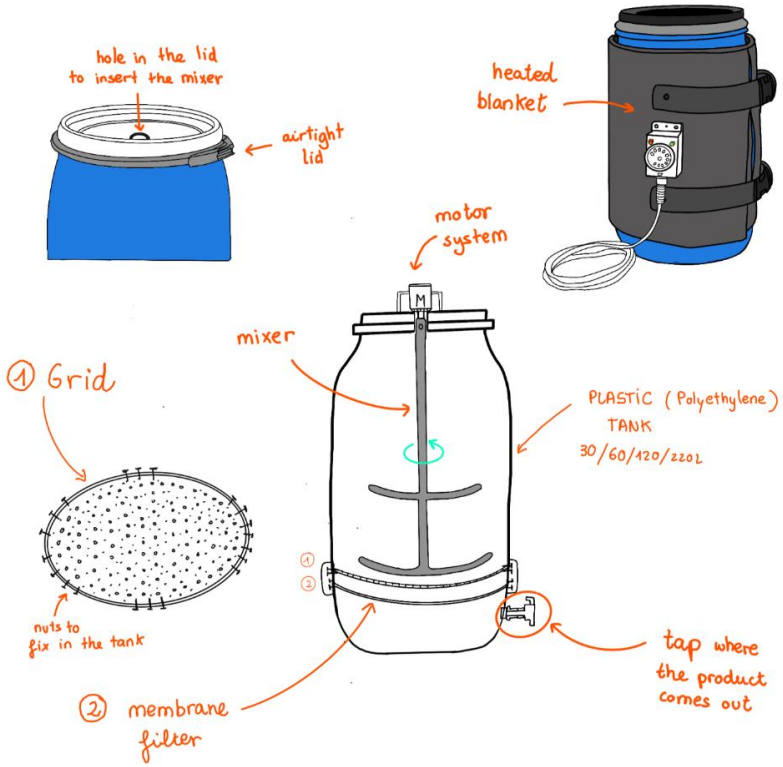


Figure 7: First tank design

To ensure our design is spot on, we used SolidWorks to create the first prototype with the exact dimensions of our fermenter tank.

In the image below, we highlight the key parts of our first 3D design and show how they will fit inside the tank.

1. Tank
2. Tank lid
3. Translucid lid
4. Mixer
5. Heater belt
6. Tap
7. Muslin filter
8. Grid filter
9. Fix lid
10. Electronic equipment

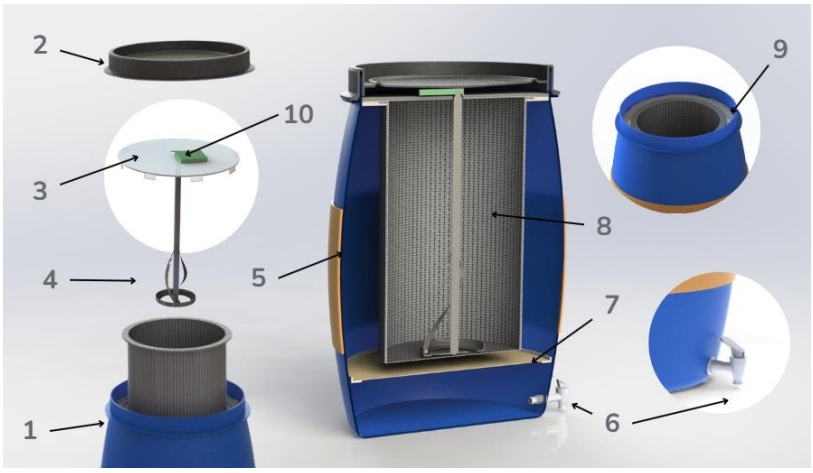


Figure 8: 3D parts of first design

5.1.4 Final design before manufacturing

Before starting the manufacturing, we made a few adjustments to the SolidWorks design. We decided to change the arrangement of the filters to streamline the oil extraction process. The fabric filter will now cover the mesh filter. However, we are adding a structure to hold the motor system, we decided to put all the motor structure in the cover to make the manufacturing part easier. We also add a box to hold the Arduino components and we remove the tap to prevent air or product leaks during the process.

Figure 9: Tank 3D design

5.1.4 Manufacturing

Filter

The filter was built in an unusual way as you can see in the design part we chose to go with a tea bag design, to accomplish this we thought of buying 2 trashcans and putting them onto each other, after this we would fix them together and wrap the filter material around the buckets. The filter was fixed using plastic collar bands.

Figure 10: First filter

Figure 11: Second filter

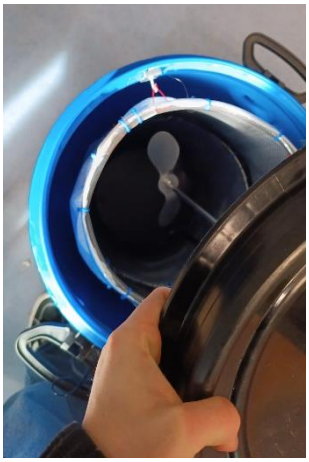


Figure 12: Filter fixed in the tank

Coupling system

For the coupling system we were looking at different options, some cheaper ones and some are more expensive. First, we went to look online on the web and found a good coupling system on amazon, sadly this part had to be shipped from China, so this was not an option and we had to find a different solution.

So, the second possible solution we thought was to cut a piece of tube and fix it onto the motor and the rotor, this solution was not really working. The tube was hard to fix onto the rotor and this resulted into a bad transmission.

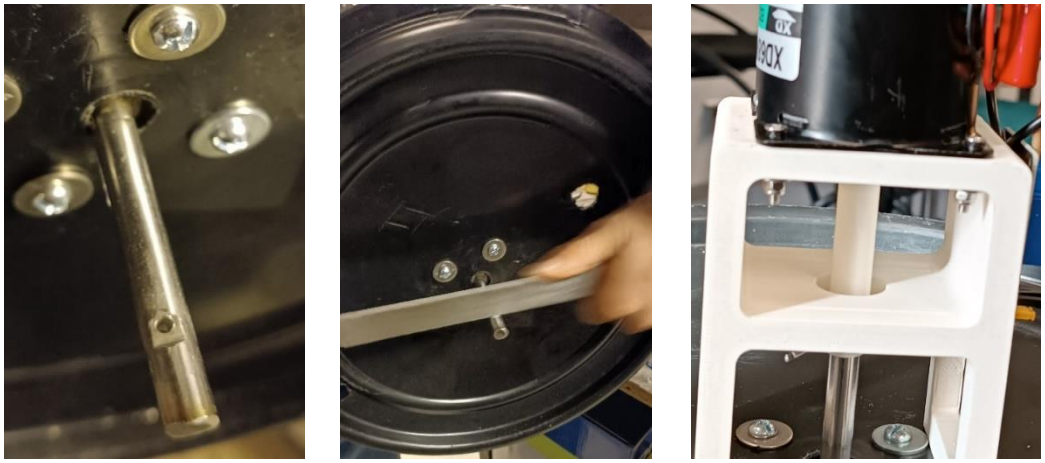


Figure 13:Coupling system assembly

So, we had to look for a new solution again, then we decided to try and make it ourselves using the 3D printer. Going with this solution one of our team members made a 3D sketch of a coupling. This solution turned out to be a fantastic success and is still currently working for the fermentation chamber.

As you can see on the pictures above this is how the last coupling system was made. The first picture shows that we had to flatten a spot on the bar so we could drill a hole into it, also the motor already had a hole to fix to when it was bought. The second picture shows that we

drilled into the bar, so the coupling system is ready to be attached to both sides as shown in full effect on the last picture. The coupling system is attached to the motor and the rotor by a pin, this is a cheap but effective solution.

Carbon filter

The carbon filter was made with an easy solution, by using a hose with a length of around 3 meters. After acquiring this there was a hole drilled into the top of the barrel just the diameter of the hose. When this was done the hose was put in and sealed of so no air could leave the barrel if it is not through the hose. When placing the barrel upstairs, we put in the carbon filter material for about 2 meters in the hose, so the air must go past the material.

Arduino box and motor support:

Let's start off with the Arduino box, this one had to be made because the Arduino and all the other components had to be protected so no cables can get unplugged or broken. The easiest way to manufacture this will be to design it ourselves and 3D print it out, this way we have the right size we need, and we made it ourselves as shown on the photo below.

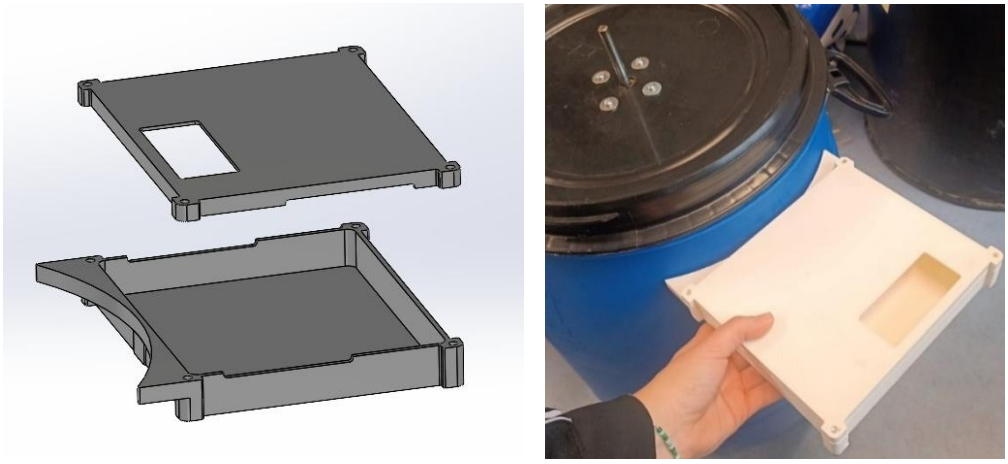


Figure 14: Arduino box design and assembly

Now let's talk about the motor support this one had to be created to support the motor onto the barrel, also important to note is that we had to connect the motor with the stirring rod, like told before we used a coupling system for this. So, with this knowledge the design could start. First we thought of making the support in a U shape only, but quickly before we manufactured the piece we were thinking about the structural strength of support.

Then the solution came to mind that the U shape gets an extra beam between the legs, this will result into an improvement in the structural strength of the support. As shown on the picture below. After all this, we had some trouble with keeping the support onto the barrel, we thought glue could had enough strength to stay when the motor was turning, this was not the case. So we looked at a different solution, where a hole is drilled into the barrel fixing it with nuts and bolts.

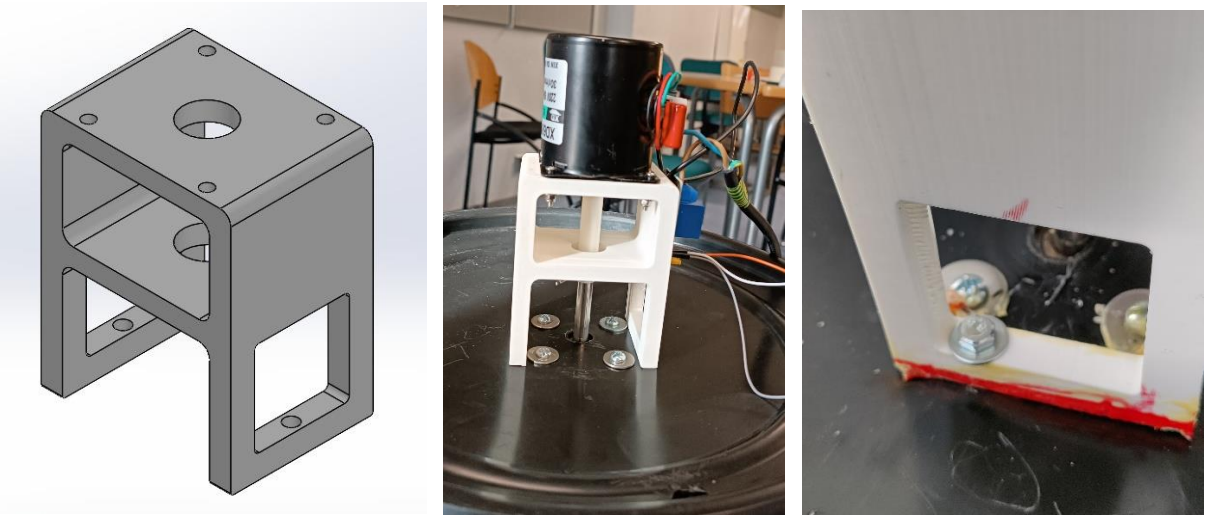


Figure 15: Motor support and assembly

5.1.5 Automation

To experiment with the method of fermenting fish waste, to obtain the finished product known as “Garum”, we thought it would be interesting to set up a stand-alone device. Indeed, we think that this solution will be the most interesting for fishermen, and if they wish one day to make “Garum” with their fish waste, they will need an autonomous device so that it does not take them too much time to take care of it, which would make the device less profitable.

So, we decided to automate our plastic tank model using an Arduino board. Thanks to this, we will be able to monitor important values via various sensors to ensure that our mixture does not go wrong. We will also be able to automate the stirring of the mixture, as we need to stir it at least once a day.

Sensors program

As explained above, we are going to follow certain values to make sure our mixture does not go wrong and become poisonous. After some research, we have found that the easiest way to tell if garum is going bad or not is to smell the mixture. It is not going to smell good in any case, but if the smell is unbearable, that's a bad sign. As this was not very precise, we asked about the fermentation process itself to find out the important values to follow. We saw that we could monitor temperature, pH, electrical conductivity, or even test the solution to detect any contaminants. (Wikipedia, 2024) As we do not know much about chemistry, we have decided to follow fairly simple values, detectable by sensors we can use with Arduino, and at the end of the process, we will probably send a sample of our garum to a laboratory to test it and find out whether it is fit for consumption or not.

So, we are going to monitor the temperature inside the tank, which needs to be between 25°C and 35°C for fermentation to proceed smoothly. So, we are going to monitor the temperature

inside the tank, which needs to be between 25°C and 35°C for fermentation to proceed smoothly.

Next, we will monitor the pH of the filtered liquid solution we obtain in our tank. When making Garum, the pH should always be between about 4 and 5. It should not stray too far from these values. If the pH starts to rise too much, it may mean that fermentation is slowed down or stopped by something like contamination, ammonia production, which would mean too much decomposition of the waste, which can be caused by too high a temperature for example. If the pH drops too much, it will not be alarming at first because a drop in pH can be caused by increased microbiological activity. However, if the pH drops too much, it may be due to contamination of the mixture.

Figure 16: Temperature sensor

Figure 17: Temperature Ph

These two sensors will be placed in the tank, and thanks to the Arduino, we will be able to display the values read by these sensors live on an LCD screen on the side of the tank. Thanks to this, we will just have to check from time to time that the values displayed are within the tolerance range and are not going awry, which would indicate that fermentation is going badly and that our final product will be poor.

Heat belt

After switching on our test device, we realized that the temperature varied enormously. Indeed, at this time of year, the nights can be very cold with temperatures close to 0°C, and during the day, in the roof hut where we stored our tank, the temperature could easily rise to around 40°C due to the sun. We realized that we needed to connect our heating blanket to our Arduino to activate and deactivate it according to the situation. We therefore used a relay to enable the heating blanket to activate if the temperature inside the tank was below the 25°C required for proper fermentation. As the blanket is constantly set at 30°C, the relay will cut power to the blanket when the temperature is above 30°C. Thanks to this, we improve fermentation conditions and therefore have a better chance of successful fermentation. However, we will probably have to find a solution to keep the temperature in the hut from rising too high, as we do not have anything to lower the temperature in the tank.

Figure 18: Heat belt

Motor program

Another crucial step in fermentation, and not the least, is the obligation to stir the mixture at least once a day so that fermentation takes place correctly. For this, we decided to automate this stirring. We will therefore use a relay controlled by Arduino, which will allow us to run the motor aiming to stir the mixture, every 4 hours for 1 minute. To find the approximate power of the motor we need, we looked at the characteristics of the motors used on existing mixers, sold complete. So, we found that a power of about 25 or 30 WATT should be enough. We decided to use a rather simple and inexpensive motor that we can have on Amazon, which is a high-torque (2.5 rpm) permanent magnet synchronous reduction motor with a power of 28 WATT. This engine is not going to run fast, because we do not need speed, we only need torque, to stir all the pieces of fish, even if there are big ones. Moreover, we will use an Arduino clock, the DS1307-Module-VO3, which we will use as a "timer" to limit the use of "delay" in the program. The clock will therefore be set to 3 hours 59 minutes and 55 seconds in the setup part. Once in the "loop" part, the motor is engaged when the clock is at 4 hours 0 minutes 0 seconds, for a duration of 1 minute. By setting the clock to 3 hours 59 minutes and 55 seconds in the setup part, we will wait just 5 seconds to see if the motor is running well, when we reset the program or the first time, we power the Arduino. Once stuck in the "loop" part, the clock will be reset to 0 hours 0 minutes and 0 seconds to have the 4-hour timer. In addition, the timer value will be displayed on the LCD screen placed on the side of the tank.

Figure 19: Clock

Figure 20:Relay

Figure 21: Motor

By using the clock as a timer, we will have no problem in the event of a power cut. If the Arduino is unplugged and then plugged back in, everything will restart automatically. Our tank is therefore in theory autonomous from the point of view of mixing the mixture, which is an essential point because for fishermen who would like to use this type of device, having to mix everything regularly every day is a significant waste of time.

To finish, we can see the diagram of our Arduino wiring with all the components that we used to make our fermentation experiment device as autonomous as possible:

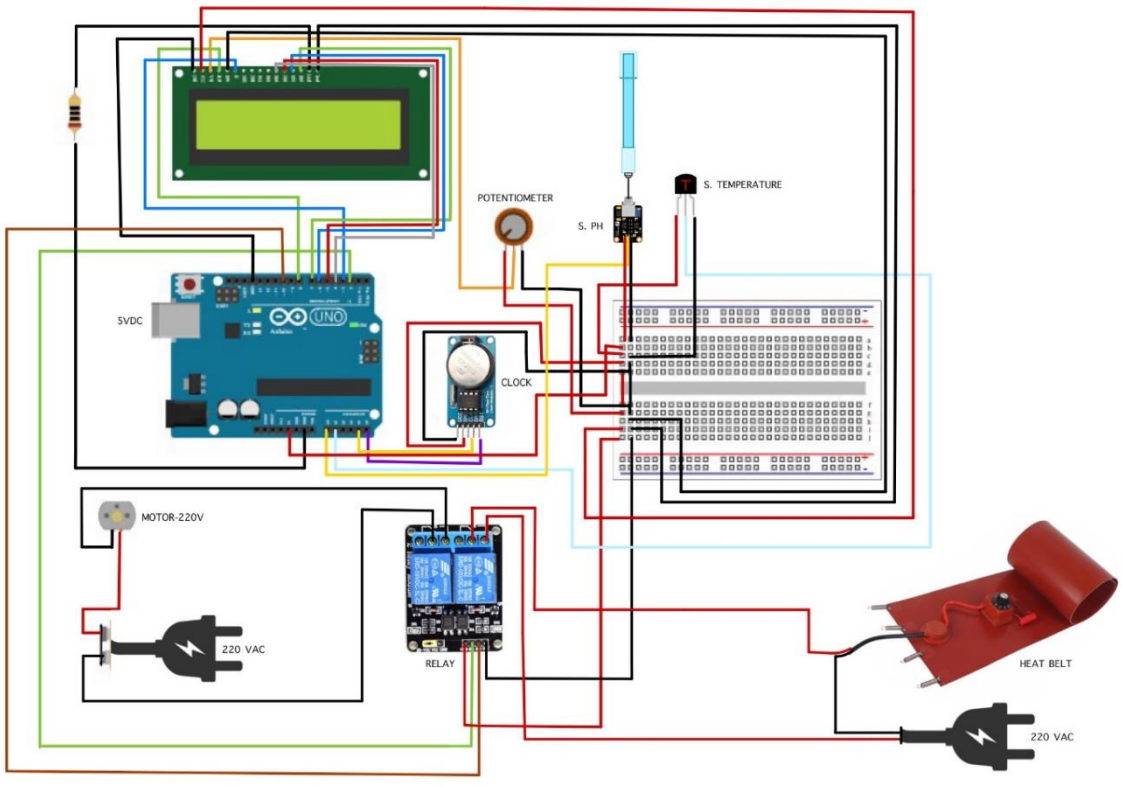


Figure 22: Electronic connections

You can find the Arduino code in the appendix (10.1)

5.1.6 Installation of air pump in the roof

To try and solve the problem of too much heat in the roof shack, we decided to install a ventilation system that would activate once a certain temperature was reached in the shack. It is the only solution we have. We meticulously positioned the electrical wires in a strategic path within the plastic cover of the roof shack, ensuring they would not be inadvertently severed as we cut a circular hole for the fan installation. With precision, we fitted the cooling fan into place. Afterwards, we calibrated the settings to regulate the temperature within the shack, efficiently cooling it down from temperatures exceeding 30°C to a comfortable 24°C before the fan automatically halts its operation.

We therefore hope that this system will suffice to limit the heat inside the shack, and thus avoid degrading the quality of fermentation in our barrel.

Figure 23: Air pump hole

Figure 24: Air pump installation

5.1.7 Obtaining process

In the following sketch we can show the process of the fish fermentation to obtain two main products. The **first drawing** depicts how the salt and fish waste are placed inside the initial filter. As weeks pass under suitable conditions, the fish waste will undergo a change in texture. In the **second drawing**, we can observe that a portion of the fish has fermented and passed into the second phase of filtration, through the muslin. In the **third drawing**, we can see that the fermentation process has been completed, resulting in two completely separated products: on one hand, the fish skeleton and other solid residues, and on the other, the liquid substrate.

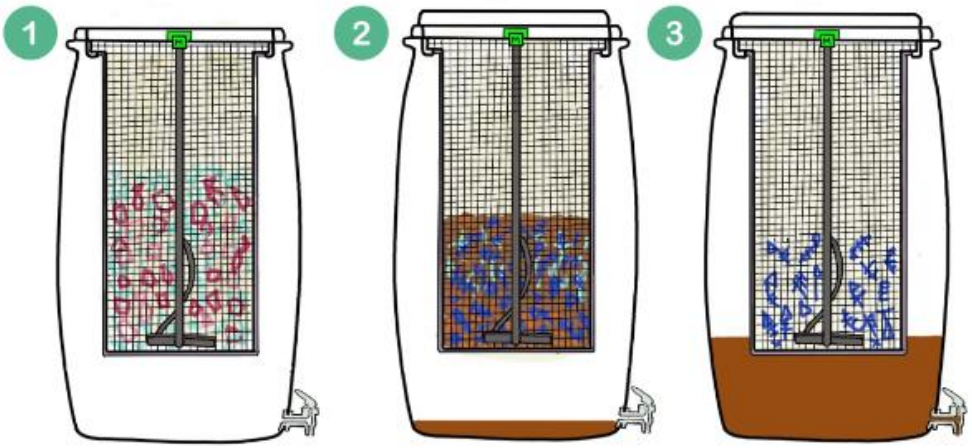


Figure 25: Sketch of fermentation process

In the first prototype of the tank, we did not put the tap for the extrusion of the liquid, but in a future version we will add the tap to make the extrusion easier.

5.1.8 Final Result

Figure 26: Ineer tank fermentation

Figure 27: Final tank

5.1.9 Improvements

Motor

The motor of the barrel should be changed to a stronger one, so we are able to put in more fish waste and thus get more garum from the fish. Now if we put too much fish waste into the barrel the motor stops turning because it can't deliver the power that we need from it. So, in our opinion the only solution to this problem is going to be to get a stronger motor to improve the barrel further.

The rotor/stirring

The stirring system in the barrel works fine but could be improved, the bar that is connected to the rotor bends a bit inside of the barrel when it gets difficult to stir and the rotor itself is easy bendable, but it still works.

Figure 28:Inner tank

The Lid of the barrel

The lid or top of the barrel needs to be stronger the plastic top is not strong enough, when the motor aplies pressure on to the plastic top and it starts to bend a bit. This does not cause to much problem but to keep in mind that it has to survive for months alone. The solution should be more robust. So I would recommend using a stronger material or find a new solution of where to place the motor, otherwise the barrel will not survive for a long time.

Coupling system

After a week of operation, our coupling system failed, so we immediately modified it for increased durability by increasing the outside diameter. Despite the significant cost savings associated with plastic components, we decided to retain them. However, if the problem persists, we are inclined to switch to metal parts to avoid this happening again.

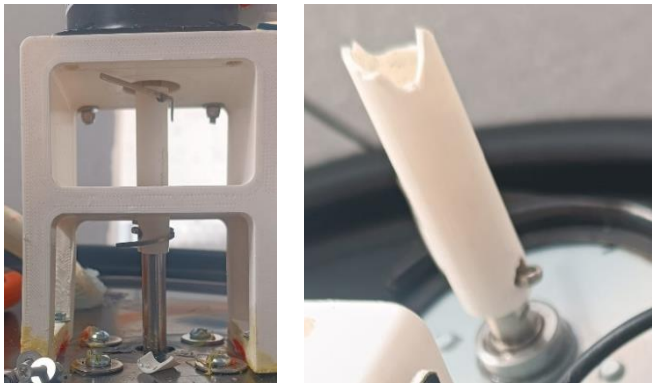


Figure 29: Coupling system failed

Tank

We do not know yet if our product will work, but we believe that using a metal tank instead of a plastic one for fish fermentation has several advantages. Firstly, metal tanks are more resistant to pressure, reducing the risk of deformation or breakage during the fermentation process. They are also better able to withstand sudden temperature changes, which helps to maintain stable conditions within the tank. In terms of chemical resistance, metal is less susceptible to corrosion than plastic, making it more suitable for fermentation processes that can produce aggressive chemicals. Metal tanks are also easier to clean and disinfect, reducing the risk of cross-contamination and ensuring the quality of the final product. Finally, metal tanks tend to have a longer service life than plastic tanks, making them a more cost-effective long-term investment.

5.1.9 Estimated cost

The cost for the barrel with everything used to make it. (note: we did not count that you must buy/ use a hand drill and the drills itself, we used this all from the toolroom in Technobotnia):

- Tank 60L plastic barrel = 55,20€
- Heated blanket = 62€
- Bin x2 = 10€
- The white cloth for filter = 10€
- Plastic pipe = 2€
- Carbon for carbon filter = 5€
- Motor = 30,59€
- Cable + plug for motor 10€
- Arduino (price of the box with all components) = 53€
- pH sensor = 39€
- Temperature sensor = 12€
- Relay = 7€
- Mixing device = 13€
- Small price: steel wire, plastic zip ties, silicone, bolts, clips for coupling system, 3D printing pieces, glue, scotch tape = 30€

Total price = 338,79€

5.2 Collagen extraction

5.2.1 Information of collagen

The utilization of marine-based collagen is growing fast due to its unique properties in comparison with mammalian-based collagen such as no risk of transmitting diseases, a lack of religious constraints, a cost-effective process, low molecular weight, biocompatibility, and its easy absorption by the human body. Marine collagens, derived from sources like fish skin, bone, cartilage, and scales, have garnered attention for their superior bioavailability compared to collagen from bovine or porcine sources. Research indicates that marine collagens are absorbed more efficiently by the body, with a potential absorption capability up to 1.5 times higher. This enhanced absorption is attributed to their low molecular weight and small particle size, which facilitate rapid circulation in the bloodstream. (Polymers (Basel) ,2020)

Different extraction methods can be performed based on the marine sources. However, the general procedure of collagen isolation includes preparation, extraction, and recovery.

The preparation mostly consists of washing, cleaning, the separation of animal parts, and size reduction by cutting or mincing the samples for facilitating the following pretreatment of the

samples (J.A, B.S, V.W, N.T, T.M, 2005). After the preparation, a mild chemical pretreatment is performed to increase the efficacy of the extraction and remove non-collagenous substances. Generally, depending on the raw materials and the extraction method, different pretreatments can be performed (alkaline or acid treatment). Pretreatment is used with a diluted acid or base to break down the crosslinked collagen before the extraction because of crosslinked collagen in the connective tissue of animals (S.M, D.R, M.R, K.E, M.M, K.A, D.I, 2016).

5.2.2 Collagen applications

Collagen has been utilized in various industries. It finds applications in biomedical materials, the pharmaceutical industry, cosmetics, and food, where it has been used in the production of functional foods (Paul and Bailey, 2003).

This has led to the creation of products such as creams, gels, lotions, and masks, as well as subcutaneous injections for direct application to the skin. Collagen-based shampoos, conditioners, and hair treatments have also been developed to prevent signs of weakening. Additionally, as previously mentioned, collagen has been utilized in the development of patches, dressings, or gauzes, which offer significant benefits in wound healing by accelerating tissue repair, reducing local inflammatory response, and aiding in reducing bacterial load. Various studies have also been conducted to demonstrate collagen's applicability as a biomaterial in tissue engineering, biodegradable packaging materials, and photographic films, where it is responsible for fibre stiffness and strength. (V.R, L.J, 2019)

5.2.3 Extraction without previous stabilization method

For collagen extraction, we have tried two methods before using any stabilization method. What we have used to perform the two collagen extraction treatments is the fish skin that contained more scales.

The first method that we tested was the **acid extraction.** This procedure involves using acids to hydrolyse the collagen present in the fish sample and solubilize its chains in an acidic solution. This entails immersing the pieces of fish skin in an acidic solution, such as acetic acid (AcOH) or hydrochloric acid (HCl), for a specified period of time. The interaction between the acid and the collagen molecules breaks the crosslinks present in the collagen helix and increases the extraction efficiency. Subsequently, the solubilized collagen chains can be obtained in the solution, facilitating their further isolation and purification for use in various applications. (B.C., W.Q., R.X, 2021)

The steps we have followed to complete the Acid Extraction procedure:

1. Wash and clean the fish skin/scales until it turns white
2. Measure the weight of the skin, water, and acetic acid. Depending on the quantity of skin you have, adjust the litres of water and acetic acid accordingly. The ratio of skin to acetic acid is 1:10, meaning there are 10 times more skin than acetic acid.
3. Mix water with acetic acid, the ratio is 1:10, 10 times more water than acid acetic.
4. Immerse the fish skin pieces in the prepared acid solution
5. Wait for 24 hours. Depending on the type of fish, the duration may vary
6. Filtrate the acid solution
7. Collect the filtered solution in another clean container
8. Refrigeration to conserve

Figure 30:Acid extraction collagen procedure

After the process of obtaining collagen through the acid extraction method, we should have obtained a gelatinous texture. We did not achieve this, and it could be due to improper refrigeration after the experiment or miscalculations in proportions.

The second method that we tested was **acid hydrolysis.** This type of hydrolysis involves the prolonged boiling of proteins present in proteinaceous substances using acids such as HCl and AcOH. These acids hydrolyse the triple helix of collagen, solubilizing its chains into shorter peptides in solution. The interaction between the acid and collagen molecules breaks the cross-links in the collagen helix, enhancing the extraction efficiency. Although acid extraction methods are commonly used for collagen isolation, the high acidity, prolonged processing time, and high temperatures in acid extraction methods can negatively induce significant degradation of soluble collagen chains. (Żelechowska y col., 2010)

The steps we have followed to complete the Acid Hydrolysis procedure:

1. Wash and clean the fish skin/scales until it turns white
2. Measure the weight of the skin, water, and acetic acid. Depending on the quantity of skin you have, adjust the litres of water and acetic acid accordingly. The ratio of skin to acetic acid is 1:10, meaning there are 10 times more skin than acetic acid.
3. Mix water with acetic acid, the ratio is 1:10, 10 times more water than acid acetic.
4. Immerse the fish skin pieces in the prepared acid solution
5. **Boild the solution 30 minutes**
6. Filtrate the solution
7. Collect the filtered solution in another clean container
8. Refrigeration to conserve

Figure 31:Acid Hydrolysis collagen procedure

After the process of obtaining collagen through the acid hydrolysis method, we obtain a gelatinous texture. This process works well, and we successfully accomplish the extraction of collagen.

5.2.4 Extraction after freezing

For the extraction of collagen after freezing, we soaked the fish in a vinegar solution using the same steps as for the acid extraction, the only difference being that we then put it in the freezer. After 48 hours we took it out and let it defrost in warm water. The fish waste consisted mainly of fish skin and bones.

Next, we transferred it to a stockpot with a lid and heated it on low for about 30 to 40 minutes, making sure it did not boil.

After that, we removed the stockpot from the heat and let it cool for around 30 minutes. Then, we strained it using a strainer to collect the liquid, which we called collagen.

Unfortunately, the collagen did not meet the standard, and we couldn't test its quality.

Our setback was the ratio of vinegar to fish skin was not entirely proportional, due to the quantity of skin as well as much information on the ratio as well.

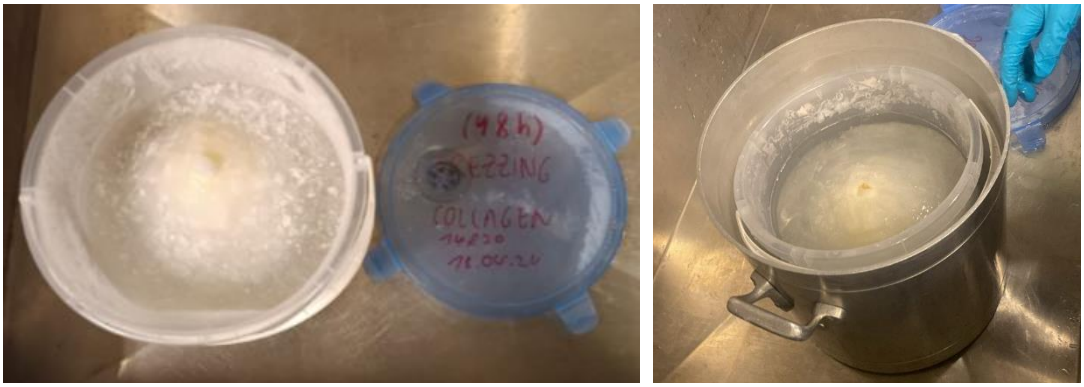


Figure 32: Extraction of collagen after freezing procedure

5.2.4 Extraction after pickling

After a lot of research, we decided not to test collagen extraction after pickling because this method does not seem to be conducive to that. Putting all the parts of the fish in the pickling will not allow you to have enough collagen to harvest or this collagen may not be interesting because it will be mixed with a lot of things and the vinegar will surely deteriorate it.

5.2.5 Results of collagen extraction

To conclude on the different methods, we used to extract collagen, we can say that the Acid Hydrolysis method has yielded the best results. We believe this experiment worked better as we learned from the errors of the Acid Extraction process and took greater care with the measurements and proportions of each component. Consequently, we conducted the experimentation with smaller quantities and achieved good results.

After trying to extract collagen after freezing, we realized it took a long time and did not give us the texture we wanted.

We would have liked to have more fish waste to repeat the processes that failed us and strive for better results in this part of the work.

5.3 Fat and oil extraction

We decided to extract fat and oil from fish using three methods. Firstly, we aimed to extract it without subjecting the fish waste to any stabilization process. The second method involved extraction after freezing the fish waste, and the third method involved extraction after pickling.

5.3.1 Information on fats and oil

Fish fats and oils are highly valued for their nutritional benefits, including omega-3 fatty acids such as EPA and DHA, which support heart health, brain function and inflammation regulation. They are mainly composed of polyunsaturated fats, which are considered beneficial for cholesterol levels and heart health. They also contain fat-soluble vitamins such as A and D, which are important for vision, the immune system and bone health. A convenient way to access these health benefits is through fish oil supplements. Fish oils are also used in various industries for their hydrating, anti-inflammatory and nutritional properties. (F. Shahidi et al., 2018)

5.3.2 Extraction without previous stabilization method

We opted to extract fats and oil from fresh fish waste without employing any stabilization methods.

Initially, we removed the undesirable parts of the fish such as the kidney and liver and the scales. Vital parts like the heads, tails, bones, and trimmings are rich sources of fats and oil. Subsequently, we placed these fish remnants into a stockpot and heated it.

After approximately 40 minutes on low heat, we observed a noticeable change in color, with the liquid turning a brownish hue and becoming infused with oil, emitting a pleasant aroma. At this point, we removed the stockpot from the heat and sieved the mixture while simultaneously crushing and pressing the fish waste.

Following this step, we allowed the sieved liquid to cool down, allowing the fats and oil to rise and settle at the surface. Using a pipette as our available equipment, we carefully collected the fats and oil from the top layer and transferred them into a small plastic bowl.

Unfortunately, the quantity of extracted oil was not as substantial as we had anticipated. We concluded that the amount of fats and oil extracted may vary depending on the type of fish used. In this experiment, we utilized Salmon as our primary fish source.

Figure 33: Oil extraction before without previous stabilization method

5.3.3 Extraction after freezing

The second thing we tested is to collect the fish oil and fish fat after freezing them in order to see if freezing alters or not the quantity and perhaps also the quality of the fish oil that it has. can be recovered from fish waste. To do this, we started by freezing a good quantity of fish waste.

Figure 34: Fish waste freeze

After that, we defrosted everything, in order to boil it to extract the oil from the fish waste. Once we boiled everything in water, we filtered the mixture, then let the liquid sit to allow the oil and fat to rise to the surface of the container to collect it.

Figure 35:Fish oil extraction after freezing

Once this was done, we were able to collect the oil and fat using pipettes for small spoons and store it in a box to use it later.

5.3.4 Extraction after pickling

To continue, we tried to collect fish oil in a fish waste pickling solution. We were a little surprised but recovering fish oil after picking fish waste seems to be the best way to enhance the value of the pickling method. Indeed, the pickling process facilitates the release of fish oil from fish waste as it often involves the use of acidic or saline solutions that break down cellular tissues and release the oils. So we tried to pick our fish waste and then extract the oil.

To extract fish oil after pickling fish waste, we need to follow some steps. First, we must collect pickled fish waste in acidic or saline solutions. Then we can leave it for several months without worrying about it. In our case, we left it on for 20 days, as we were coming to the end of our semester.

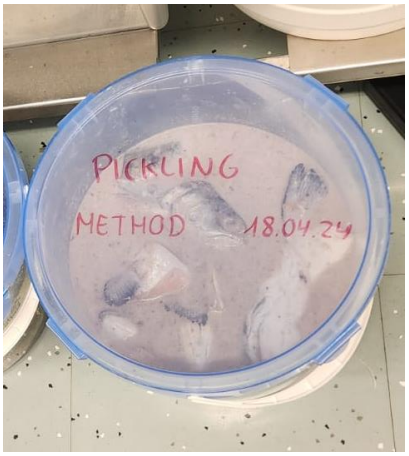


Figure 36:Pickling bucket

Then, we need to separate the solids from the liquids using filtration or centrifugation methods to isolate the solution containing the fish oil. Once we have the liquid solution, we must proceed with oil extraction using methods such as distillation, application of pressure, or solvent use, depending on the specific characteristics of the solution. In our case, we first tried to press the whole thing to extract the fish oil, but as we did not have a press, we did not manage to do it properly. So we decided to boil the whole thing, as we had done to extract the oil on previous occasions. After that, we filtered the mixture.

Figure 37: Residues of pickling extraction

As we can see, the pickling followed by boiling has almost completely removed the fish waste, and we can no longer distinguish the heads, only the remains of meat and a few bones. Once the filtration was complete, we left it to rest, to allow the oil to rise to the surface and then recover it.

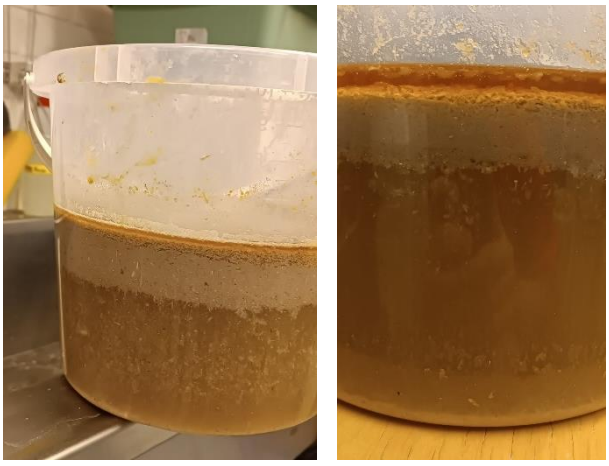


Figure 38: Pickling fish oil extraction bucket

As we can see, the result is nothing like what we have had before. In fact, we can clearly see that the oil layer is much thicker than in other extractions we have done. We were therefore able to collect this oil with pipettes easily and in large quantities.

Figure 39: Fish oil extraction with pipettes

After this extraction, the best thing would probably have been to have our oil tested by a laboratory to make sure it did not contain any bad substances, but due to time constraints we went straight to using this oil to make our soaps, which we will present to you later. So we were able to test the pH of our soaps to find out whether they were good or not.

5.3.5 Results of fats and oil extraction

To conclude on the different methods we used, the method without freezing or pickling, directly with fresh fish waste, allowed us to obtain an average result, which allows us to have a basis for showing the advantages and disadvantages of each of the processes tested.

First can say that the pickling method was a big surprise. In fact, we clearly saw the effectiveness of this method, which makes it easier to extract the oil from the fish, as well as being a very effective preservation method, since the fish remained at room temperature in the pickling box for 20 days, and the mixture did not go bad. We believe that pickling has helped to better collect the oil from the fish, as the vinegar in the solution will help to dissolve the fats and thus facilitate oil extraction.

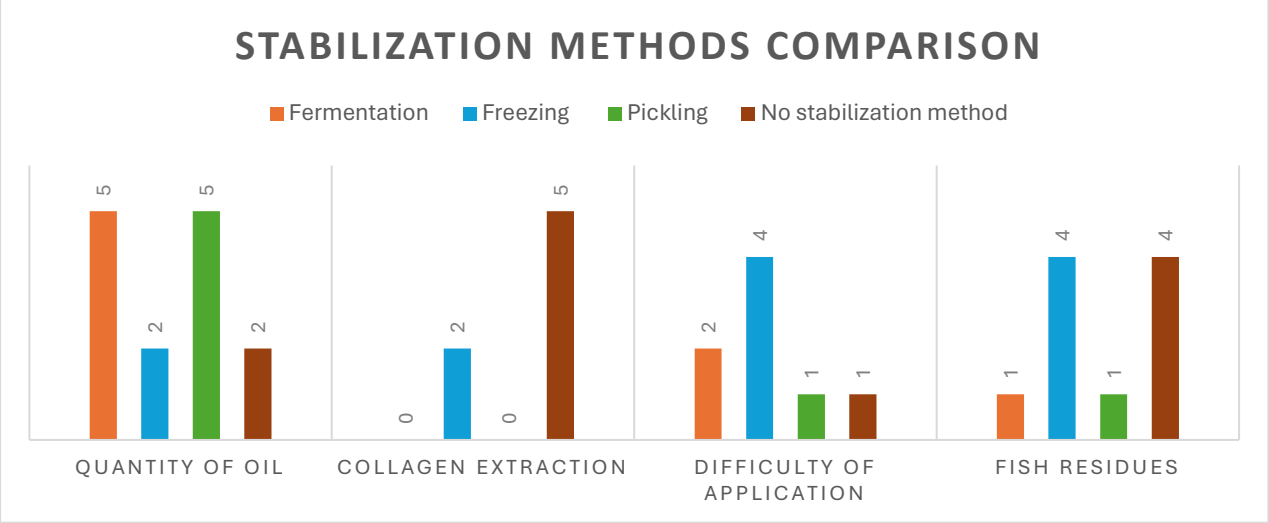
To follow, we saw that the worst result was with previously frozen fish. In fact, we obtained the least amount of fish oil with these fish, using the same process. This just goes to show that freezing is a good means of preservation but will greatly alter fish waste. Indeed, during freezing, ice crystals will form, and these crystals can damage the fish cells and disrupt the structure of its tissues, which can reduce the amount of recoverable oil. What is more, during thawing, some of the water contained in the fish waste will drain away, taking with it some of the oil present in the fish waste. As we thaw our fish waste by passing it under hot water and leaving it soaked in hot water, we must have lost most of the fish oil.

Figure 40: Different levels of fish oil depending on the method

5.4. Methods of stabilization conclusion

5.4.1 Comparison of the results

In order to compare the different methods, we have prepared a comparison table summarising the results obtained. There are four aspects to each method, and we have given each one a score from 1 to 5. These aspects are the amount of oil obtained, the ability to obtain collagen, the difficulty of application and the amount of fish residues after the procedure. In the first and second aspects, a good and maximum score is a 5 because we are talking about the amount of usable material, and in the third and last aspect, the worst score is a 5 because we are talking about the difficulty of the process and the unprofitable fish parts.



The quantity of oil obtained refers to how much oil is extracted from the fish during the process, which affects the efficiency of the extraction method. For this aspect we evaluate with a fermentation method because we believe that we will obtain good results and also pickling method because we obtained a lot of quantity respecting the other ones. For the collagen extraction process we evaluate the ability to obtain collagen, so we put bad results in pickling and fermentation because the extraction it was not possible.

To continue, in the difficulty of application we valorise the assessments of how easy or difficult it is to apply the extraction method in practice, considering factors such as the time spent on the process, the equipment needed. We gave the lowest score to freezing because it is easy to do, but at the same time defrosting to get the product is a waste of time. We valued the other methods because the process is not complicated. Finally, post-extraction waste refers to the material left over from the fish after extraction, which has an impact on waste management. We have found that pickling and fermenting leave less residue and more usable product after each process.

In conclusion, the pickling process has given promising results, although further verification will be required to confirm the quality of the product that is obtained. Although it is not possible at this stage to draw a definitive conclusion on the fermentation method, initial observations suggest that it is working effectively and that no significant foul odours have been detected in the mixture.

6. Final Product with Fish Waste

6.1 Hand Soap

Using the oils and collagen obtained from our extractions, we decided to craft hand soaps. To add a fun twist and enhance our project's appeal, we chose to 3D print fish-shaped molds for the soap creation.

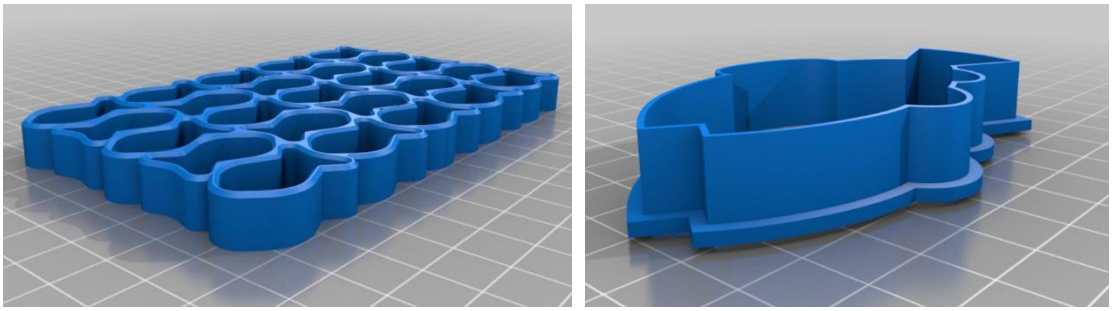


Figure 41: Soaps molds

6.2 Soap process

The process of making hand soap primarily entails 3 ingredients and 3 steps. We begin with specified proportions: 900 g of oil, 234 g of water, and 115 g of caustic soda, which we have tailored for our testing purposes. Once we have adjusted the proportions to match our desired product quantity, we can proceed with the following steps: first, pour the caustic soda into the water (never the reverse, as it can pose a danger) and mix until the solution is homogeneous. Meanwhile, heat the oils on a fire to 40-50ºC. Once both substances are warmed, combine the oil solution with the other mixture. Blend thoroughly until the mixture thickens, leaving a noticeable trail when lifted with a spoon.

To finish, pour the substance into molds and let it sit for 24 hours. After the 24 hours have passed, demold and let it rest for 4 weeks in a cool place.

We have done this process twice, altering the proportions of fish

Figure 42: Accurate measurement of ingredients

6.2.1 Soap using 12% fish oil

In this experiment we tried to make soap for the first time, the goal was to just create soap using some fish waste and see if this is an actual solution for the future of fish waste. To start we used the combination of fish oil, collagen and coconut oil to create the soap. For measurements we used: 500g of coconut oil, 60g of fish oil and collagen, 128g of water and 64g of caustic soda.

So, the process can start now that we know the measurements, just follow the instructions told before. So, to say it shortly you mix the water and caustic soda, you mix the oils and wait for both to cool down until 30 degrees and then you put them together and blend it. After you put it into the molds and wait 24h, after this you take them out and let them rest for 4 weeks.

Figure 43:Soap production process

This process was a success in our minds, for doing the soap for the first time it came out successfully and there is a lot we have learned from doing this process. Note that we do not think this is already a final product, but this experiment shows that it is possible to do with the fish waste and should be looked further into by the next group, if there is going to be one of course.

6.2.2 Soap using 100% fish oil

In this case, we used 228 g of fish oil obtained from the pickling extraction method, 60 ml of distilled water, and 29 g of caustic soda.

When we did the soap process we thought that it has worked correctly, but a few days later we saw that the soap is not hard enough. We conclude that we could add more caustic soda to do the soap in this case to make harder, put we believe that we can obtain soap using 100% fish oil. This indicates that for future experiments, we could add more fragrances and ingredients, as we have established the efficacy of the fish oil.

Figure 44:Soap production process

6.2.3 Quality standard

To ensure the safety of our products, it is necessary to check the pH to ensure it is not harmful to the skin.

The ph of the soap using 12% of fish oil is between 9-10 and the measurement of the using 100% of fish oil and it was between 10-12.

In both cases, we have obtained a basic pH. It is slightly higher than that of normal soaps, but in no case is it acidic, so it is still usable as a hand soap. (Rebbeca, 2023)

Figure 45: Ph measurement of 12% fish oil soap

Figure 46: Ph measurement of 100% fish oil soap

6.2.4 Estimated cost (750cl)

The cost to make 1L of fish oil depends on what you want to use to create the soap. If you would like to make the first soap process, we did with 12% then you can look at the list to know the cost.

- Fish waste = free
- Distilled water = 4€ for 5L
- Caustic soda = 6€ for 700g
- The 3D printed molds = free at school
- Scale = 15€
- Measure cup = 2€
- Coconut oil 500g = 8€

Total = **35€** if you buy everything

But it costs 9,20€ if you only want to buy the caustic soda, water and coconut oil for making the process and achieving 750cl of soap material. With this you could make a lot of soap like you can see in the picture bellow.

Figure 47: Result of fish soap 12%

6.3 Garum

The garum product is what we will get if our fermentation tank works properly under the conditions set for the next 2 months. Garum is a liquid condiment appreciated in ancient Rome and the result is a concentrated liquid rich in proteins, containing omega-3 fatty acids and serving as a great source of nutrients. The liquid should be thick, dark in colour and have a strong flavour.

Figure 48:Garum

Although we won't be able to see the final result, we hope that the next groups working on the project will be able to make good use of it and our research to obtain it.

7. Conclusion of the project

To conclude we are going back to the objectives set in the beginning of the project:

To summarise, our group has gained valuable insights into the abundance of fish waste and effective methods for its stabilization. Throughout this project, extensive research led us to what we believe are optimal approaches for repurposing fish waste. Our exploration of three specific methods yielded significant learnings, pickling resulted in an abundance of oil but little else, freezing showed promise in collagen extraction, albeit with the drawback of a lengthy defrosting process, and fermentation, though initially to design and manufacture, ultimately with the next group it is going to be very promising to get garum out of it so Mikael can finally try out the garum to taste it.

As we wrap up our work, the ongoing fermentation process will be monitored, with Mikael scheduled to assess its progress. Encouragingly, our experiments with soap production using fish oil yielded promising results. The formulation utilizing 12% fish oil and the remainder coconut oil proved successful, only the smell must be improved. Conversely, the soap composed entirely of fish oil requires further refinement, particularly in achieving the desired hardness and smell, necessitating adjustments in caustic soda quantities an avenue for exploration by subsequent teams.

In conclude, this project serves as a solid foundation for future teams. Whether building upon our findings or leveraging them to inspire fresh initiatives, it offers a springboard for continued innovation and exploration in the realm of fish waste utilization.

7.1 Personal feedback

7.1.1 Fayaad

Working on the fish waste project was new for me. I did not know much about fish waste before this. But during the project, I learned some programming and how to use Arduino to control temperature. We used a timer to make a motor turn a mud mixer at the specific times. I also learned how to make soap from fish waste, even though it was not perfect, it was good and exciting. We also figured out how to get useful things like collagen, fat, and oil from the waste in diverse ways, though not standard.

The fish smell was something I got used to. And I learned a lot about working with others and managing time. Listening to everyone's ideas and trying different things together was a big part of the project. Overall, it taught me a lot about teamwork and trying new stuff.

7.1.2 Nora

When the project was proposed to me, I was initially unsure of how I would approach it, as I had no prior knowledge of the subject. However, as a future industrial design and product development engineer, I saw this challenge as an opportunity to grow and learn.

During the process, we delved into the knowledge of fish waste and explored its possibilities as an undervalued resource. Through this experience, we learned the importance of sustainability and eco-design in product development. It is an exciting emerging trend that is set to become an integral part of the industry. Its aim is to create solutions that contribute to environmental preservation and sustainable development.

7.1.3 Timothy

Doing this project, I learned a lot about the fish waste and how to stabilise it, the studies I did before however did not have a lot to do with what we learned here. Although it was still interesting to do, seeing what skills I can apply to bring the project to a good ending. At the end I am happy to see the finishing results we have achieved and had a lot of fun while enjoying my time here in Finland. One thing that is certain I will go home with more knowledge than I had before. Finally, I hope our research can be used for the future and have an impact for the next team to come.

About the experience, at the beginning I was not looking forward to working with the fish waste, but eventually when we had to the smell was not so bad, it just smelled like you were standing in a fish market. Although I would not recommend letting the fish just stand outside for a couple of days because the smell can get worse pretty quickly.

7.1.4 Quentin

This project allowed me to discover and learn new things. It did not have much to do with my studies, but I found it interesting to discover new things. What is more, the aim of the project was to reuse fish waste, which would make better use of the earth's natural resources and help reduce waste. Nowadays, anything is possible to limit our waste and the impact of humans on our planet. What is more, our project aims to improve the incomes of local fishermen, which I think is a good thing too.

Apart from that, I have been able to improve my Arduino coding skills thanks to this project but also discover working in a group with people from diverse cultures and therefore practice my English.

In terms of experiences, I thought that working with fish waste was going to be a very bad experience with very bad smells. But once I started cleaning and sorting the waste, the smell was not so bad, and the waste was not so disgusting, so it was not so disgusting to work on this project. What is more, knowing that the project is likely to be passed on to another team who will continue our work is also motivating and interesting.

8. Project Management Work

8.1. Belbin Roles

8.1.1 Nora Brugada test

Below, I present my Belbin analysis and my own conclusion.

Overview

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	2	0	1	1	1	3	2	0
2	0	3	0	1	2	1	0	3
3	0	0	2	1	0	1	3	3
4	0	1	1	1	0	2	3	2
5	0	1	1	1	0	4	0	3
6	0	1	0	2	2	1	4	0
7	2	2	2	0	0	2	0	1
Tot	4	8	7	7	5	14	12	12

think act

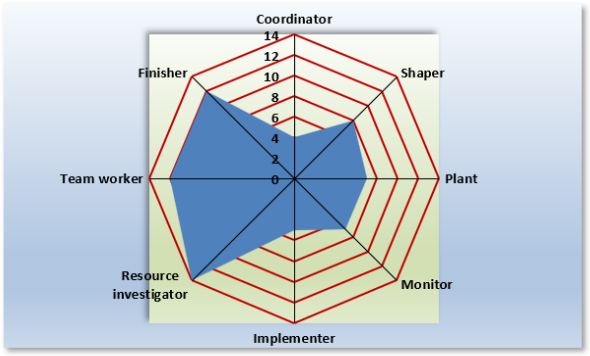


Figure 49:Nora Belbin test

If we observe the results, we can see that I stand out as a **Resource investigator**. However, I also have good scores as a Team worker and Finisher. According to the highest roles, I am a very outgoing, enthusiastic, and communicative person. I believe I am, but I do not express myself very well in English, so I do not think it is one of my strengths here. However, I do identify with the roles of **Team worker** and **Finisher** since I adapt very easily and enjoy working in a team, while also being very perfectionistic and wanting everything to turn out perfectly polished. I also tend to worry and become anxious when things are not going as expected, but at the same time, I am motivated to find solutions.

According to the test, my weakest role is that of a **Coordinator**, but I do not believe I am entirely deficient in this area. Additionally, I think it is important to consider that proficiency in a particular role may vary depending on the context and circumstances.

8.1.2 Quentin Rames test

Here we can see the result of my Belbin test:

	Coordinator	Shaper	Plant	Monitor	Implementer	Resource investigator	Team worker	Finisher
1	2	0	0	1	2	1	1	3
2	2	1	0	1	1	0	2	3
3	1	1	1	2	1	0	1	3
4	2	2	0	1	2	0	0	3
5	1	3	0	1	0	2	3	0
6	0	2	1	1	1	2	2	1
7	3	2	1	0	1	1	2	0
Tot	11	11	3	7	8	6	11	13

think act

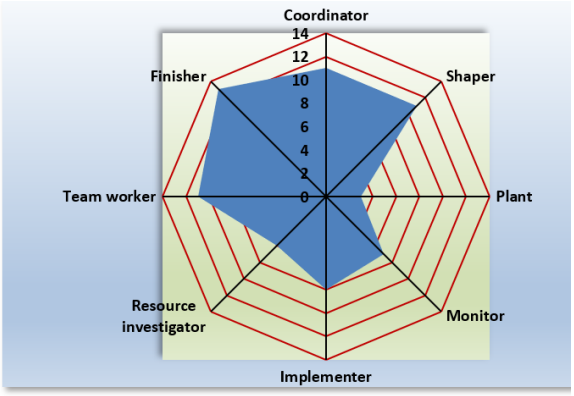


Figure 50:Quentin belbin test

According to the Belbin test, I am a "finisher". On the presentation of the roles, we can see that the "finisher" is an anxious person, searching the perfection for the project and for who it can be difficult to delegate.

I recognize myself in this role. I like when the work is well done and I ready to work a lot to obtain a quality job. Of course, my main obsession is to finish the work before the deadline, having done everything I could to make the project as perfect as possible. As a result, it is difficult for me to delegate important tasks if I do not know well people in my group.

Finisher will allow to see if, during the project, the group deviates from his goal but also to do a quality job during all the projects.

To continue about my roles, according to the test, I am also "Team Worker", "Shaper" and "Coordinator". In fact, I recognise more myself on the role of "Team Worker" but not really. For me, cohesion is very important in a team in order to achieve a good job, but I do not think that I am able to improve the cohesion in a group by myself. But I think I can sometimes have the weakness of this role by, being indecisive and maintaining uncommitted positions during discussions and decision-making.

As for the other roles, "Shaper" and "Coordinator", I think I am different from them, but in certain exceptional situations I can undoubtedly behave in a way that comes close to them.

8.1.3 Fayaad Babs-Khalid test

In the following section, you will find the results of my personal Belbin test, and my analysis of the said results.

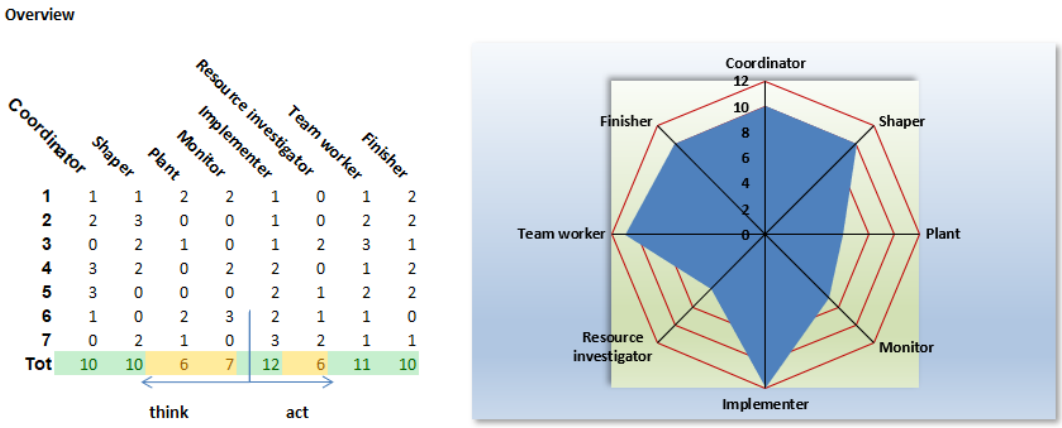


Figure 51:Faayad belbin test

Looking at the graph, we can see that my main role is an implementer, then the next to it is a Team Worker, then a Finisher, Coordinator, and a Shaper which share equal test scores. Followed by Plant and Resource Investigator which are the lowest of all.

Following Belbin's role description of the implementor, I can agree with the fact that, am passionate about getting things done amicably and ascertaining that everything is done precisely and how it is planned even if the concepts are not my ideas. I only do not agree with the resource investigator because I believe that, am resourceful when it comes to finding information.

8.1.4 Timothy Mous test

Below you see a screenshot of my personal Belbin test where I talk more in detail about:

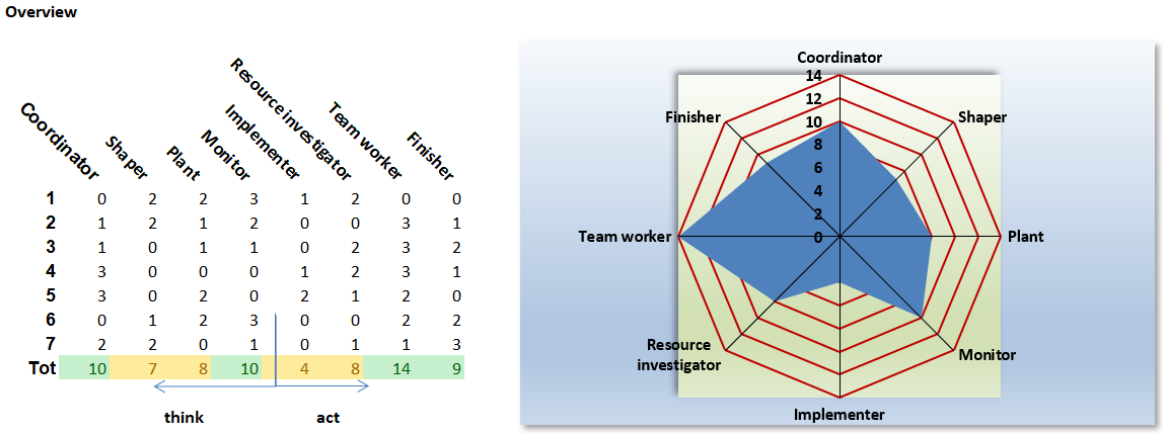


Figure 52: Timothy belbin test

If we take a look at the results of my personal Belbin test, we can see that I have the highest score on Team Worker:

I do see myself in it because It is always important that everyone is working in a team to achieve an accomplished project. The positive part about being a 'Team Worker' is that I can listen to everyone's opinion and try to look at it from a diplomatic perspective. Now there are also some downsides about being a 'Team worker', I could be very indecisive and try to avoid confrontation. I do see myself in this description because I will always try to listen to everyone and try to look at it from every single perspective, also I try to avoid confrontation.

My second highest score is a tie between Coordinator and Monitor.

I do not really see myself as a coordinator, I am mature and can come over as confident, but I will always doubt myself to see if I am doing the right thing. However, I see myself as a Monitor, I will always try to look at every option there is and try to make the best decisions with the options we have, the drive is most of the time there, but I do lack in the inspiring others.

Some of my negative qualities are the implementer, and I think it is right, because a good implementer is more practical and reliable but not that flexible to other ideas that again shows that this is the complete opposite of me.

8.1.5 Balbin test comparison

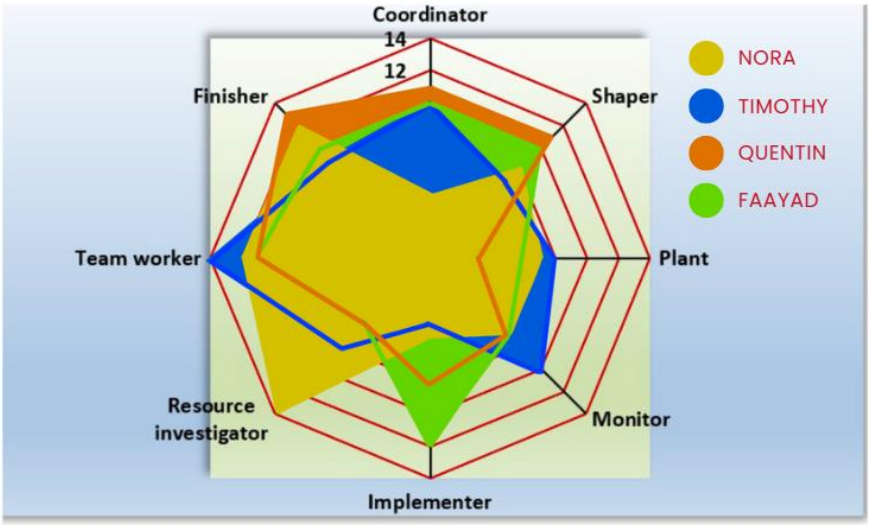


Figure 53: Belbin test comparison

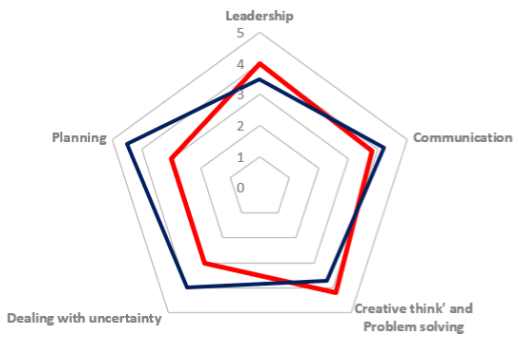
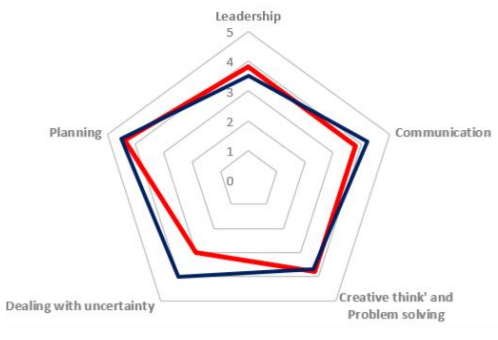
As a team, we excel in roles such as Finisher, Team Worker, and Resource Investigator, where our strengths lie. Comparing these roles, it is evident that the team members have a diverse range of strengths and weaknesses. Nora and Timothy both excel in promoting team harmony, while Quentin and Fayaad show strengths in driving the team towards goals and ensuring tasks are completed to high standards. Each member brings unique qualities to the team, and by understanding and leveraging these differences, the team can work together

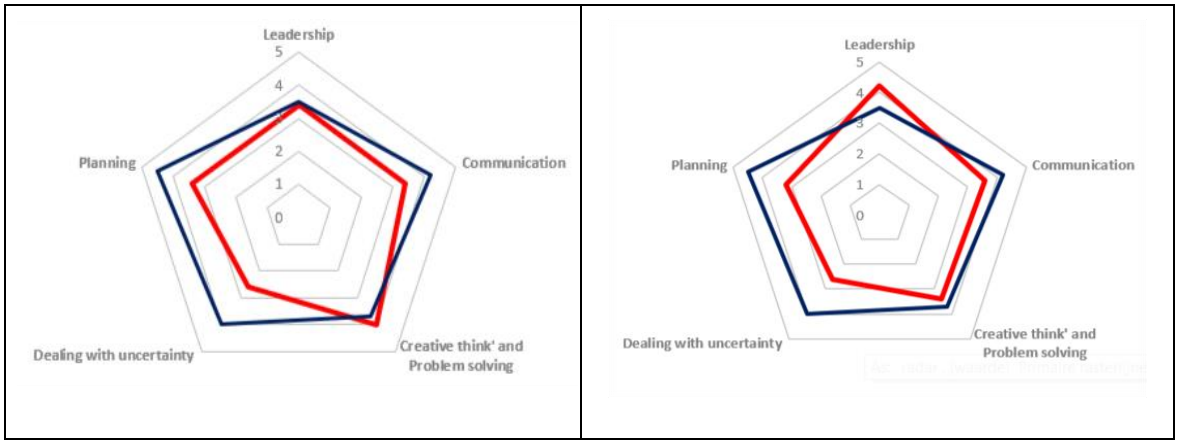
more effectively towards their goals. However, we recognize that we are lacking behind in roles like Plant and Monitor. Therefore, it is imperative for us to dedicate effort towards improving these weaker skills in order to enhance our team's overall effectiveness and cohesion.

8.2 Leadership Skill Radar

Here we have a comparison table to determine who would be a better leader in a group project.

Characteristics	Typical project manager	NORA	QUENTIN	FAYAAD	TIMOTHY
Leadership	3,5	4	3,8	3,4	4,2
Communication	4,2	3,8	3,8	3,4	3,6
Creative think' and problem solving	3,7	4,2	3,8	4	3,4
Dealing with uncertainty	4	3	3	2,6	2,6
Planning	4,5	3	4,4	3,4	3,2

NORA	QUENTIN
	
FAYAAD	TIMOTHY



Based on the scores provided to assess completeness as a leader, we can infer the following:

- Leadership: Timothy scores 4.2, suggesting solid leadership skills, although not the highest among team members.
- Communication: Nora leads in this aspect with a score of 3.8, indicating a considerable ability for effective communication.
- Creative Thinking: Nora excels again, scoring 4.2, suggesting a notable ability to generate innovative ideas and creative solutions.
- Dealing with Uncertainty: Nora and Quentin are tied with a score of 3, indicating an average ability to handle uncertain situations.
- Planning: Quentin leads in this aspect with a score of 4.4, demonstrating exceptional planning and organizational skills.

Additionally, there is Fayaad, who maintains consistent scores across all aspects without excelling in any particular area.

In conclusion, while each team member shows strengths in specific areas, none stands out as the most complete leader in all categories. Timothy excels in leadership, Nora in communication and creative thinking, Quentin in planning, and Fayaad contributes with consistent performance across all aspects. However, the ability to deal with uncertainty seems to be an area requiring more attention and development for the team as a whole.

Project charted can be found in the appendix 10.2.

8.3 Scope Management

Here we are going to talk a bit more about the scope of the project. The scope in our project is a substantial one, this is because it can go in many different ways. It will all depend on what we think and what we can do with the information we gathered about the project, of course the budget also plays a large role in this. For last we have to also realise we try to go outside of our comfort zone to find the best possible solution to the problem at hand.

8.4 Work Breakdown Structure

The Work Breakdown Structure (WBS) is an essential methodology in project management. By breaking down the project into smaller, manageable tasks, the WBS provides a clear vision of the objectives to be achieved. Each component of the WBS assigns specific responsibilities, thus facilitating task allocation within the team. Additionally, this structure organizes the project in a way that makes cost and schedule estimation more precise. Furthermore, the WBS offers the necessary flexibility to manage changes throughout the project. In summary, the WBS improves planning, communication, and overall project management, ensuring efficient execution and stakeholder satisfaction.

WBS can be found in the appendix 10.3.

8.5 Time Management, communication and resources

8.5.1 Project schedular and responsibility

Creating a project scheduler at the project's outset is crucial. It clarifies tasks, aids resource allocation, and helps anticipate risks. The scheduler acts as a guide, ensures smooth communication, and serves as a reference to track project progress. In short, it lays the foundation for successful project execution.

The project schedular can be found in the appendix 10.4.

8.5.2 Time management

Effective time management is critical in projects like this, as it directly impacts task progress. To manage our time effectively, we must first identify the tasks at hand and their importance to the project. Task planning typically prioritizes tasks based on their significance, ensuring that we allocate our time appropriately.

8.5.3 Communication Strategies

Initial Setup: We have created a **WhatsApp group** for its simplicity and familiarity and for faster and easier communication.

Ongoing Collaboration: Microsoft Teams will be our primary platform for communication within the team and with our supervisor, Mikael. This includes both chats and video calls.

Meetings: We will schedule regular face-to-face meetings in familiar locations like the EPS room.

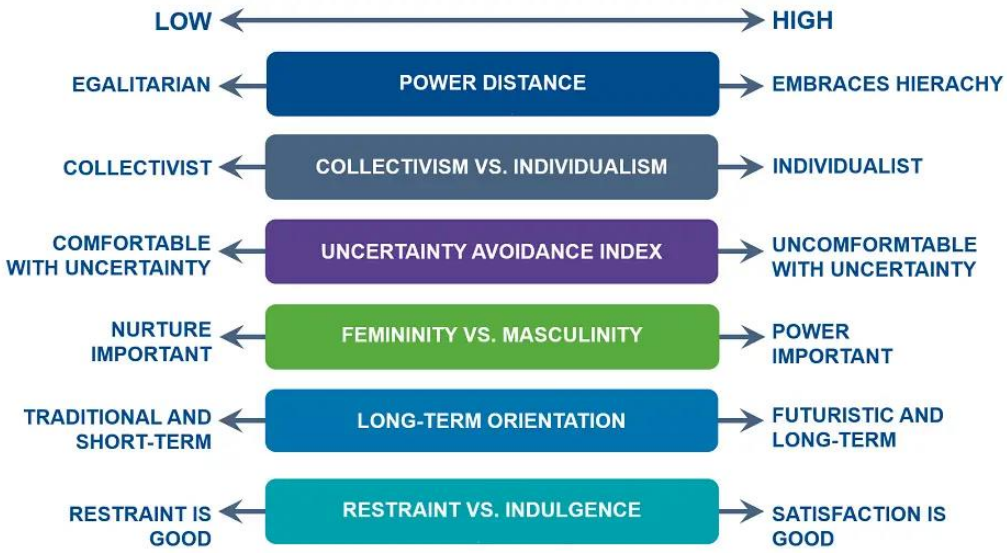
Documentation and File Sharing: Microsoft Teams and **OneDrive** will be our main tools for storing and sharing project documents. These platforms allow for real-time collaboration and easy access from anywhere with an internet connection.

8.5.4 Resources

Novia will provide facilities and resources for our project. Our project supervisor, Mikael, has allocated rooms for our experiments and will also procure the necessary materials and equipment to ensure the success of our project. He has also connected us with other personnels who can help us with field beyond our scope of knowledge.

8.6 Team Communication

Team communication in the context of Hofstede's cultural dimensions refers to how cultural factors influence the way teams communicate within an organization. Hofstede's cultural dimensions theory identifies several key dimensions that impact communication styles:



Understanding these cultural dimensions can help teams navigate cross-cultural communication challenges, adapt their communication styles to accommodate diverse cultural backgrounds, and foster effective collaboration and teamwork in multicultural environments. In this project, our team comprises individuals from four different nationalities: Spanish, Belgian, French, and Ghanaian. While we come from diverse language backgrounds, English serves as the primary language for communication and instruction. Although some of us may face challenges in expressing ourselves fluently, we have effectively addressed this barrier and remain focused on reaching our goals and objectives.

Our team is composed of Belgian, French, Spanish and Ghanaian people.

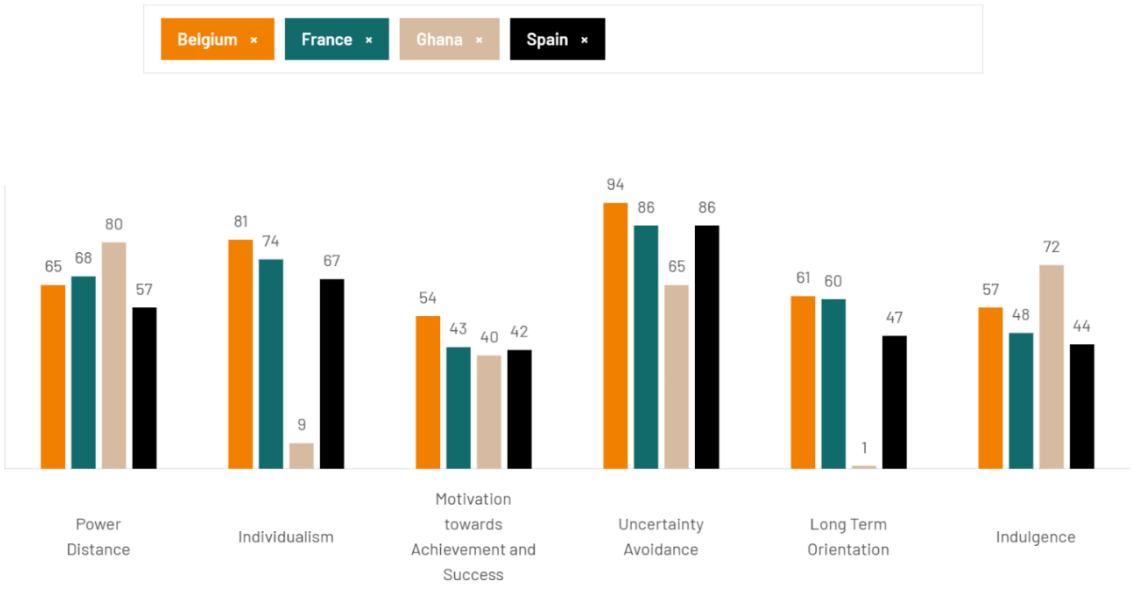


Figure 54:Hofstede's cultural dimensions comparison

8.6.1 Fayaad- Ghana conclusion

Typically, Ghana exhibits a collectivist culture, prioritizing community and group identity over individual accomplishments. Conversely, Belgium, Spain, and France lean towards individualistic cultures, valuing personal goals and self-expression. Nonetheless, these are broad generalizations, as individual beliefs and values vary within each culture.

To elaborate, Ghana places significant emphasis on community and collective identity, often prioritizing group needs over individual desires. This is evident in the value placed on extended family, communal activities, and a sense of belonging to a larger community. On the other hand, Belgium, Spain, and France embrace more individualistic cultures, where personal achievements, self-expression, and individual rights are highly esteemed. Individuals in these societies often prioritize independence, autonomy, and pursuing personal aspirations.

These cultural disparities manifest in various aspects of life, including decision-making, social dynamics, and work environments. For instance, in Ghana, decisions are frequently made collectively, considering the viewpoints and needs of the community, whereas in individualistic cultures, decisions tend to be based on personal preferences and individual considerations.

It is essential to recognize that these are broad cultural tendencies, and individuals within each country may exhibit varying degrees of individualism or collectivism based on their unique beliefs and experiences.

8.6.2 Nora - Spain (Catalonia) conclusion

Spain has a power distance score of 57. I believe this accurately reflects the numerous differences between status scales. Catalans seek to address these social disparities, starting with the removal of the monarchy. Conversely, in terms of individualism, I believe we prioritize the well-being of our close circle, seeking the best for our friends and family. While we function effectively as a society in groups, our primary concern often remains ourselves and our immediate circle.

Regarding motivation and long-term orientation, I find the score to be quite low. Some regions in Spain, like Catalonia, are innovative and actively engage in activities to shape the future. However, other parts of Spain may resist innovation or societal development, preferring a comfortable status.

Moreover, there's a tendency towards conservatism in certain aspects of Spanish culture, which aligns with the description of a restrained society.

In conclusion, Spain's socio-cultural landscape reflects a mix of tendencies, including a leaning towards preserving established norms alongside regions, like Catalonia, that embrace innovation. It is crucial to acknowledge Spain's diversity and recognize how factors such as region, age, and social class shape societal perceptions and behaviours.

8.6.3 Quentin – French conclusion

With a score of 68, France has a high score for power distance. Looking more closely at the definition of this point, I tend to agree with the results we get. In France, the concept of equality is central, and we talk a lot about it, but there is a lot of inequality and there is a very large gap between the rich and the poor. For the next point, individualism, I agree with what has been said, apart from the last sentence. Many French people do not have this need to control things or to be the best at what they do. They just do what they're told. To continue, I do not agree with the section on Motivation towards Achievement and Success. In France, success is often a source of jealousy or even malice. Apart from this aspect, many French people are motivated to succeed in life and live well. The Uncertainty part Avoidance seems to me to illustrate France well and is linked to the previous section. Very often, people's success is linked to their ability to organise and respond quickly and effectively to all kinds of problems. However, the school system does not teach French people how to react to uncertain situations, so it can be very difficult at first. The penultimate part, the long-term orientation, is quite true, but in some parts of France I think the mentality is different, especially where I come from, outside the cities and more in the countryside, where it is easier and more comfortable to stick to traditions. To conclude, the score obtained by France in the indulgence section seems rather realistic to me. In fact, the French can sometimes not enjoy life as much as they would like to, they can quickly be judged or feel judged and fear the gaze of others.

8.6.4 Timothy- Belgium (Flemish) conclusion:

To start off with power distance Belgium scores a 65, I do have to agree with this because there is a difference between the rich and poor, this is getting bigger by every year. Individualism has a score of 81, again I do understand these numbers in Belgium we live in/ eat with our family alone and do not really invite neighbours over to come and eat some food with us. But if you talk about doing something we do like to not have to do it alone or at least I feel this way. The motivation is 54 and it is understandable this number most of us have goals we want to work towards and will try to achieve it. Uncertainty avoidance is something I completely agree with it being at 94, I hate it so much when I do not know what, where or how long something is going to take. Long term orientation is close to the French with 61, as I mentioned before we look forward to our goals so we will work to obtain to them and see what happens after. For indulgence I do not really know what to add more to it.

8.7 Stakeholder's Register and Matrix

The Fish Waste project involves several stakeholders, each with unique needs and roles. Below is a breakdown of the stakeholders, their requirements, and their inclusion in the stakeholders register and matrix:

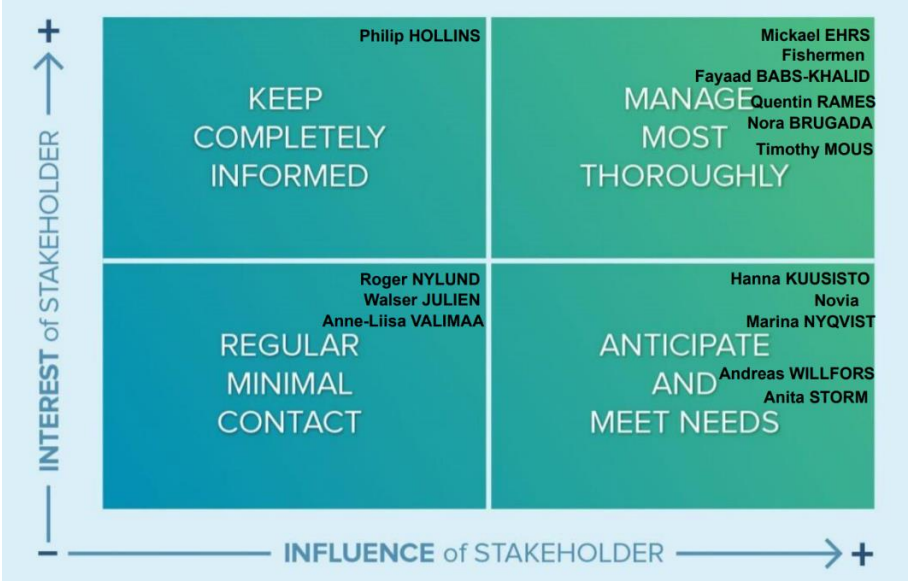
Project Manager: Timothy Mous (Internal) - Responsible for overall project delivery on time and within the stipulated budget.
Secretary: Fayaad Babs-Khalid (Internal) - Provides project support and communication.
Designer: Nora Brugada (Internal) - Creates visuals or design elements for the project, if applicable.
Accountant: Quentin Rames (Internal) - Manages project finances and ensures financial accountability.
Project Coach: Mickael Ehrs (Internal) - Provides guidance and support to the project team.
Tutor (Team Building): Roger Nylund (Internal) - Facilitates team-building activities for the project team.
Tutor (English & Cross Culture): Hanna Kuusisto (Internal) - Provides cultural awareness training to the project teams, because of students from different countries and culture backgrounds.
Tutor (Project Management): Phillip Hollins (Internal) - Offers project management training and guidance.
Novia: (Internal) - Possibly the university or organization leading the Fish Waste project.
Consultant/Researcher: Consultants and researchers are listed, with varying contact information. Their expertise aligns with the project's requirements related to fish waste utilization.

8.7.1 The Stakeholder Register

Stakeholder Register

Project Manager	Timothy MOUS	Project Phases	Initiation			
Role	**Contact**	**Category**	**Interest**	**Influence**	**Expectations**	**Comms requirements**
Project Manager	Name : Timothy Phone : +32470432580 Email :timothy.mous@edu.novia.fi	Internal	● ● ●	● ● ●	Project to be delivered on time and within budget	Group Meetings /Teams/WhatsApp
Secretary	Name : Fayaad Phone : +233245754283 Email : fayaad.babs-khalid@edu.novia	Internal	● ● ●	● ● ●	Project to be delivered on time and within budget	Group Meetings /Teams/WhatsApp
Designer	Name : Nora Phone : +34675958933 Email :nora.brugada@edu.novia.fi	Internal	● ● ●	● ● ●	Project to be delivered on time and within budget	Group Meetings /Teams/WhatsApp
Accountant	Name : Quentin Phone : +33681853708 Email :quentin.rames@edu.novia.fi	Internal	● ● ●	● ● ●	Project to be delivered on time and within budget	Group Meetings /Teams/WhatsApp
Project Coach	Name : Mickael Phone : +358447805536 Email :Mikael.Ehrs@novia.fi	Internal	● ● ●	● ● ●	Project to be delivered on time and within budget	Group Meetings /Teams/phone
TUTOR (Team Building)	Name : Roger Phone : +358505272281 Email :roger.nylund@novia.fi	Internal	○ ○ ●	○ ○ ●	Project to be delivered on time and within budget	Email and Telephone
TUTOR (ENGLISH & CROSS CULTURE)	Name : Hanna Kuusisto Phone : +358 6 328 5644 Email :Hanna.Kuusisto@novia.fi	Internal	○ ● ●	○ ● ●	Project to be delivered on time and within budget	Email and Telephone
TUTOR (Project Management)	Name : Phillip Phone : +358 46 921 5722 Email :Philip.Hollins@novia.fi	Internal	● ● ●	○ ● ●	Project to be delivered on time and within budget	Email and Telephone
	Name : Novia Phone : +358 442155139 Email :Novium@novia.fi	Internal	○ ○ ●	● ● ●	Project to be delivered on time and within budget	Email and Telephone
Consultant / Researcher	Name : Walser Julien Phone : +358505220462 Email :julien.walser@novia.fi	Internal	○ ○ ●	○ ● ●	Project to be delivered on time and within budget	Email and Telephone
Consultant / Researcher	Name : Marina Nyqvist Phone : +358505272314 Email :marina.nyqvist@fishpoint.net	Internal	○ ○ ●	● ● ●	Project to be delivered on time and within budget	Video Conference and Email
Consultant / Researcher	Name : Anne-Liisa Välimaa Phone : +358295326655 Email :anna.liisa.valimaa@luke.fi	Internal	○ ○ ●	○ ○ ●	Project to be delivered on time and within budget	Video Conference and Email
Consultant / Researcher	Name : Andreas WILLFORS Phone : +358447805738 Email : andreas.willfors@novia.fi	Internal	○ ○ ●	● ● ●	Project to be delivered on time and within budget	Meeting / Email/Telephone
Consultant / Researcher	Name : Anita STORM Phone : +358504360368 Email : anita.storm@novia.fi	Internal	○ ● ●	● ● ●	Project to be delivered on time and within budget	Meeting / Email/Telephone

8.7.2 The Stakeholder Matrix



From the above picture of the Stakeholder Matrix; This is a stakeholder matrix which serves as a tool used in project management to assess and categorize stakeholders based on their level of interest in and influence over the project. The matrix helps project managers prioritize

their communication and engagement efforts by identifying key stakeholders who have the most significant impact on the project's success. More ever, a stakeholder matrix consists of a grid with two axes: one representing the level of stakeholder interest and the other representing their level of influence. Stakeholders are then plotted on the matrix based on where they fall along these axes.

8.8 Risk Management

Risk analysis is an essential step, and one of the most important for a project, in order to bring it to a successful conclusion on time and to a high standard of quality. Indeed, in all projects, those responsible for the project, such as managers or others, must go through this risk analysis stage, whatever the nature of the project, whatever its size or complexity. The main aim is to avoid any unpleasant surprises during the execution phase, which could result in lost time or money.

8.8.1 Risk Identification and Analysis

Having clearly defined our objective and its limits, we began to look at the general risks we might face on this project. But above all, how can we try to avoid these risks or limit their impact on our project so that it runs as smoothly as possible.

To do this, we had to imagine the future of our project with a rather pessimistic vision, so as not to forget anything. This pessimistic vision is necessary because we can't rely on our "luck" to avoid all problems - we have to anticipate them.

To manage these risks, we will take a step-by-step approach:

1) Identify - Ideate the range of project "what-if" event/risks

2) Measure - Quantity using Risk Assessment Matrix

3) Manage - Complete using Risk Assessment Register

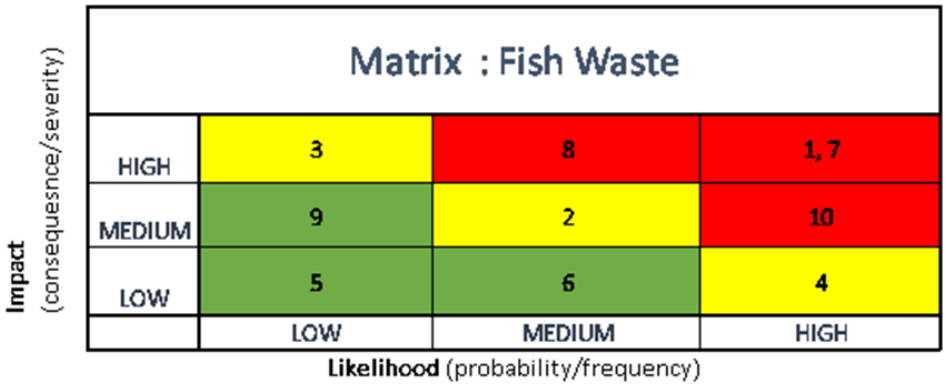
4) Monitor - Review risks and update on going as project proceeds

5) Report - Communicate outcomes to relevant stakeholders

So, the first thing we did was brainstorm all the risks we might face. By brainstorming as a group, we were able to find even more risks related to our project.

Once this was done, we created our "Risk Assessment Matrix" to format our notes and make things more visual and understandable. This matrix considers 2 aspects, the impact and the probability of the risk occurring. So, here's the list of risks and the matrix format:

ID	Risks
1	Supplier delay
2	Going over the budget
3	Delay schedule
4	Mistakes informations
5	Team conflict
6	Not enough time for the tests
7	Communication problem
8	Legislation and Regulation
9	Lack of Expertise
10	Lack of Coordination



So, we can see that the matrix clearly shows which risks need the most attention and for why.

8.8.2 Risk Register

Once this was done, we moved on to the real analysis of these risks in order to clarify them and find solutions to avoid them or adapt to those that could not be avoided to minimize their impact on our project. To do this, we created a Risk Assessment Register. In this table, we find the list of our risks, with some additional information. We then thought about the concrete impact that the risk could have, and for each risk we came up with a solution to address the problem. We also added the person responsible for the risk, i.e. the person who is most concerned by the risk, because it is important for the person concerned to be informed so as to know their working environment better and therefore be able to respond to any problems in the best possible way. And finally, we added a last column to our document in which we wrote the main things to do to respond to each of the risks. Here's the resulting document:

Risk Tracking Template : Fish Waste

Date of last review: 08/03/2024

ID	Description of Risk	Impact	Risk Reponse	Risk Level	Risk owner	Severity	Notes
1	Supplier delay	Pushes manufacture	Buy more local supplies	High	Team	III	Prefer to buy directly in shop or order early enough to make sure you don't waste time
2	Going over the budget	Cost overruns	prefer to buy lower-quality products for those that don't need to be of high quality	Medium	Team	II	Prefer products on foreign sites if we are too close to the budget limit
3	Delay schedule	Not finish the project	Follow and adapt the initial schedule	Low	Team	III	Update the gantt and try to follow it as closely as possible
4	Mistakes informations	Mistakes and lost time	Use multiple sources and talk to people	High	Team	I	Do reference table
5	Team conflict	Bad influence on the team atmosphere	Communicate well in the team	Low	Team	I	Team Building
6	Not enough time for the tests	Not enough results to compare and conclud	Respect the given agenda	Medium	Team	I	Start fermentation test first or arrange for the next EPS group to pick up a viable test
7	Communication problem	Misunderstanding	Ask questions	High	Team	III	
8	Legislation and Regulation	Solution not accepted because of a ban or law	Ask professionals and get the facts before starting any unusual tests	Medium	Team	III	Ask fishermen or other native people
9	Lack of Expertise	Miss out on innovative ideas or crucial perspectives	Do research, document yourself and ask to specialists	Low	Team	II	
10	Lack of Coordination	Uneven distribution of tasks, delays in information gathering, organizational issues	Hold regular face-to-face meetings and take the time to organise the work	High	Team	II	Remaining committed to the project

This document summarizes the risk analysis we carried out for our project. It contains all the information needed to avoid the main risks we have identified. It is an essential document that we need to keep with us throughout the project, as it may be subject to change. Indeed, during the execution phase, other risks may appear, and we will need to obtain together to think about them and add them to this document. Other risks we have already thought about may also be modified, especially in terms of how to avoid them or limit their impact.

8.9 Quality assurance

Quality is critical in a project as it ensures that the final outcome meets the expectations and needs of the stakeholders involved. It contributes to user satisfaction, confidence in the product or service, and overall project success. By investing in quality from the outset, we ensure that the project achieves its goals and delivers sustainable benefits for all parties involved.

In our case, we are working on a research project, but quality is still particularly important, as it has a direct influence on the reliability and validity of the results obtained. Ensuring high quality in research methodologies, data collection and analysis is essential to producing credible and trustworthy findings. This enables researchers to draw accurate conclusions, make informed decisions and provide valuable insights into their field of study. Without quality assurance measures, there is a risk of bias, error and inaccuracy, which can compromise the integrity and significance of research findings. Therefore, maintaining rigorous quality standards throughout the research process is essential to ensure the credibility and impact of the project.

8.9.1 Information's:

For us, quality will therefore be linked to our input data, i.e. we will pay attention to the information we find, but above all to the sources we use. We will need to multiply the sources we use to ensure we have the right information, as this will be crucial for the rest of our project. We shall additionally engage with specialists in the domain of fish waste to obtain precise information.

8.9.2 Tests:

The other important part will be the reliability of our tests and the data we collect. We will need to be rigorous in our testing and ensure the validity of our data by running several tests to compare results. So, we are going to use good-quality sensors for our tests, as cheap sensors could give false or inaccurate data.

8.9.3 Materials:

For our project, we must consider the materials used to construct the tree fish stabilizers to ensure their effectiveness, prevent material deterioration and uphold hygiene and quality standards

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10. Appendix

10.1 Code Arduino automation fermentation tank

```
//-----------------------------------------------
//--------------  DESCRIPTION-----------------------
//-----------------------------------------------

/////////////////////////////////////////////////////
/// Title: Fermentation
/////////////////////////////////////////////////////
/// Card: Arduino Uno R3
///
/////////////////////////////////////////////////////
//  Name: The Fishers
//  Date: 09/04/2024
/////////////////////////////////////////////////////

//-----------------------------------------------
//---------  PREPROCESSOR  DIRECTIVES--------------
//-----------------------------------------------
```

```
            // Inclusion of libraries

#include "Wire.h"
#include "iarduino_RTC.h"
#include "OneWire.h"
#include "DallasTemperature.h"
#include <LiquidCrystal.h>

            // Pin definition...

//change if connection change
LiquidCrystal lcd(8, 3, 4, 5, 6, 7);
//CONNECTION LCD:
//VSS on mass
//VDD alim
//V0 potentiomètre
//RS 8
//RW mass
```

```
//E 3
//D4 4
//D5 5
//D6 6
//D7 7
//A alim
//K mass

OneWire oneWire(A1);
const int relaisPinmotor = 2;    // Relay control pin motor
const int relaisPinblanket = 10;   //Relay control pin blanket

            // Variable declaration

int Hour;
int Minute;
int Second;
```

```
            // Others

DallasTemperature ds(&oneWire);
iarduino_RTC time (RTC_DS1307);


//------------------------------------------------
//-------- CONFIGURATIONS AND INITIALIZATIONS -----
//------------------------------------------------

void setup () {

  pinMode(relaisPinmotor, OUTPUT);
  pinMode(relaisPinblanket, OUTPUT);
  digitalWrite(relaisPinmotor, HIGH);          // Deactivate
relay motor
  digitalWrite(relaisPinblanket, HIGH);          // Deactivate
relay blanket
```

```
  ds.begin();                                  // Sensor activated
  time.begin();
  time.settime(00, 00, 0, 0, 0, 0, 0);    //(s,m,h,daynumber,m,y,
day) put 0 for everything
  lcd.begin(16, 2);
  Serial.begin(9600);

}


//-----------------------------------------------
//------------- INFINITE LOOP -------------------
//-----------------------------------------------

void loop () {

  Hour = atoi (time.gettime("H"));
```

```
  Minute = atoi (time.gettime("i"));
  Second = atoi (time.gettime("s"));
  ds.requestTemperatures();
  int t = ds.getTempCByIndex(0);
  int sensorValue = analogRead(8);
  float pHValue = map(sensorValue, 0, 1023, 0, 14);

  lcd.setCursor(0, 0);                    // LCD display
  lcd.print("Timer :");
  lcd.print(Hour);
  lcd.print(":");
  lcd.print(Minute);
  lcd.print(":");
  lcd.print(Second);
  lcd.print("    ");
  lcd.setCursor(0, 1);
  lcd.print("T: ");
  lcd.print(t);
```

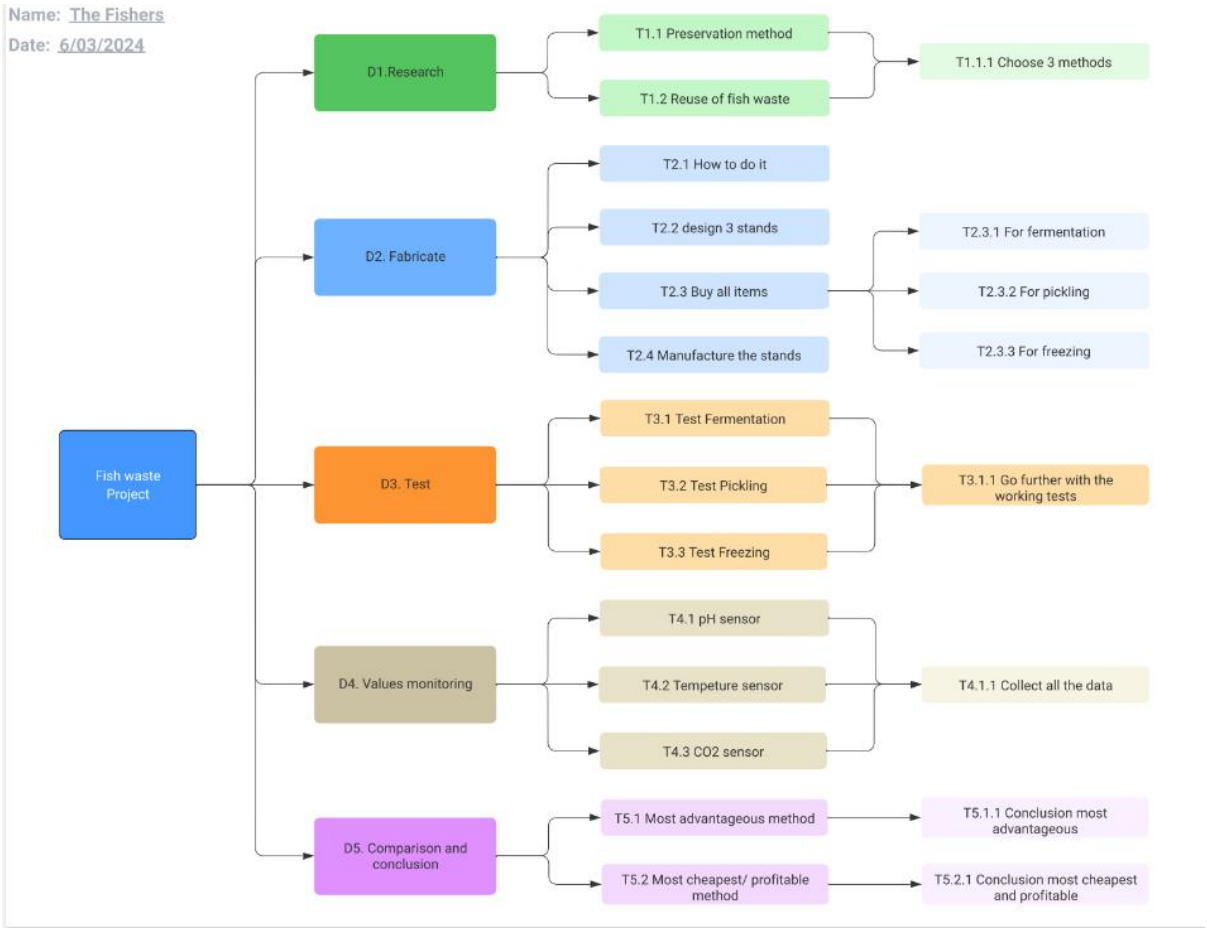
```
  lcd.print("C   ");
  lcd.print("pH: ");
  lcd.print(pHValue);

  Serial.print ("     hour : ");
  Serial.print (Hour);
  Serial.print ("     minute : ");
  Serial.print (Minute);
  Serial.print ("     second : ");
  Serial.print (Second);
  Serial.print (" ");
  Serial.println( "temperature");
  Serial.print(t);
  Serial.println( "C");

  if (Hour == 4 && Minute == 0) {          // Time between mixes
  digitalWrite(relaisPinmotor, LOW);      // Activate relay
  delay(60000);                           // Delay of spin in ms
```

```
  digitalWrite(relaisPinmotor, HIGH);     // Deactivate relay
  time.begin();
  time.settime(0, 0, 0, 0, 0, 0, 0);      // Reset clock to 0
(timer)
}

if (t < 25) {
  digitalWrite(relaisPinblanket, LOW);
}
if (t > 30) {
  digitalWrite(relaisPinblanket, HIGH);
}

  }
```

10.2 Project Charter

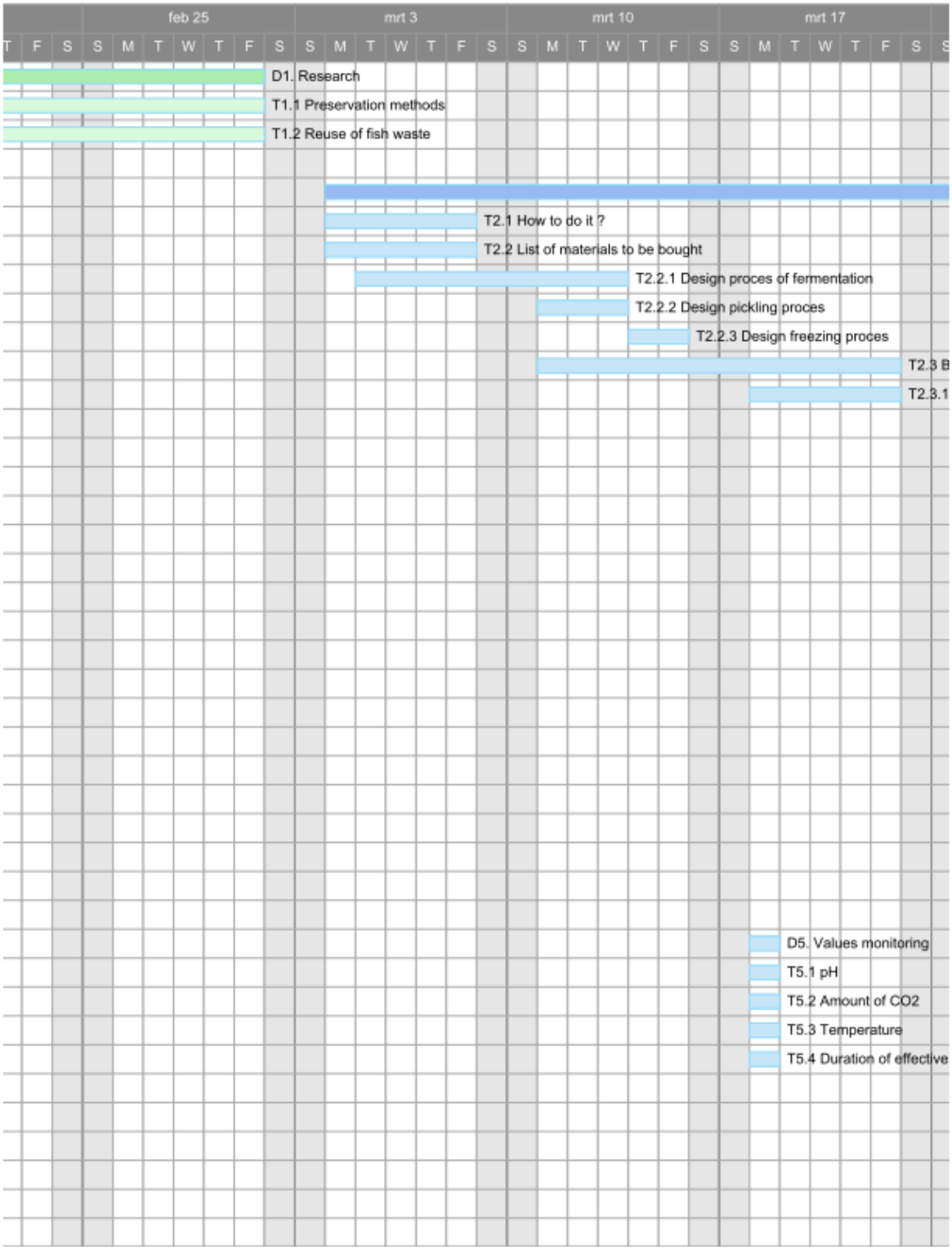
1. General Project Information		
Project Name:	Fish Waste	
Team leader:	Nora BRUGADA	
Sponsor:	Novia UAS	
Date:	01/02/2024 – 15/05/2024	
2. Project Team		
Name	**Title**	**Responsibilities**
Timothy MOUS	Project Manager	Guiding the team, responsible
Fayaad BABS-KHALID	Secretary	Communication
Nora BRUGADA	Designer	Drawing, sketches
Quentin RAMES	Accountant	Financial management
Mikael EHRS	Supervisor	Responsible, consulted, informed
Novia UAS	Sponsor	Informed
Fishermen	End-user	Informed
3. Project Scope Statement		
Project Purpose		
In collaboration with local fishermen, our project supervisor, and various external individuals whom we will be able to ask many questions, we will conduct research to evaluate existing techniques and explore new approaches to reduce waste and maximize the value of fish waste. During the 6 months of our project, we will focus on testing three selected methods, for which various prototypes will be developed. However, the project will continue for two years, allowing for a more thorough evaluation and refinement of the methods. The outcomes of this study will contribute to improving the economic and environmental efficiency of fish waste management, providing local fishermen with new revenue opportunities through waste valorisation. Additionally, this project may serve as a model for other regions in Finland and potentially be extended to other sectors, offering broader economic and environmental benefits to the fishing sector. The diversity of our team will enhance our ability to innovate and find relevant solutions tailored to the varied needs of local communities.		
Objectives		
• Search different preservation methods • Search different reuse methods • Desing and fabricate functional model to test different methods • Test all the methods • Compare and conclude about the most efficient and cheap method		
Deliverables		
• Find the most efficient and cheap method for preservation and reuse of fish waste • Propose a practical and feasible way for fishermen to use the method		
Scope		
The aim of our project is to propose the most interesting methods for preserving and reusing fish waste. We will be testing different methods to ensure the reliability of the methods that we will present at the end of the project. The aim of our project is not to sell concrete final product, but rather to find the most interesting method for fishermen or other people who might be interested.		

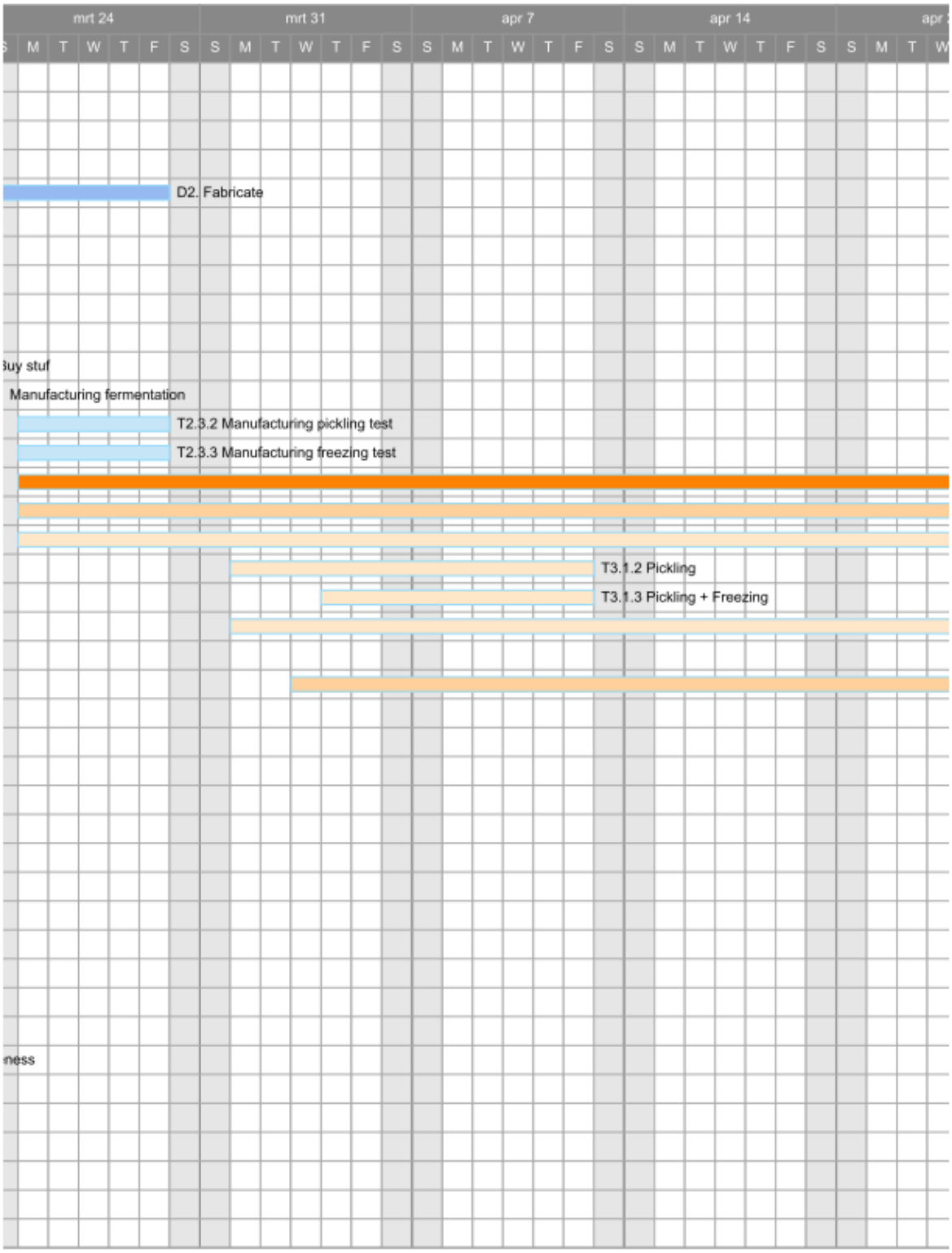
10.3 WBS

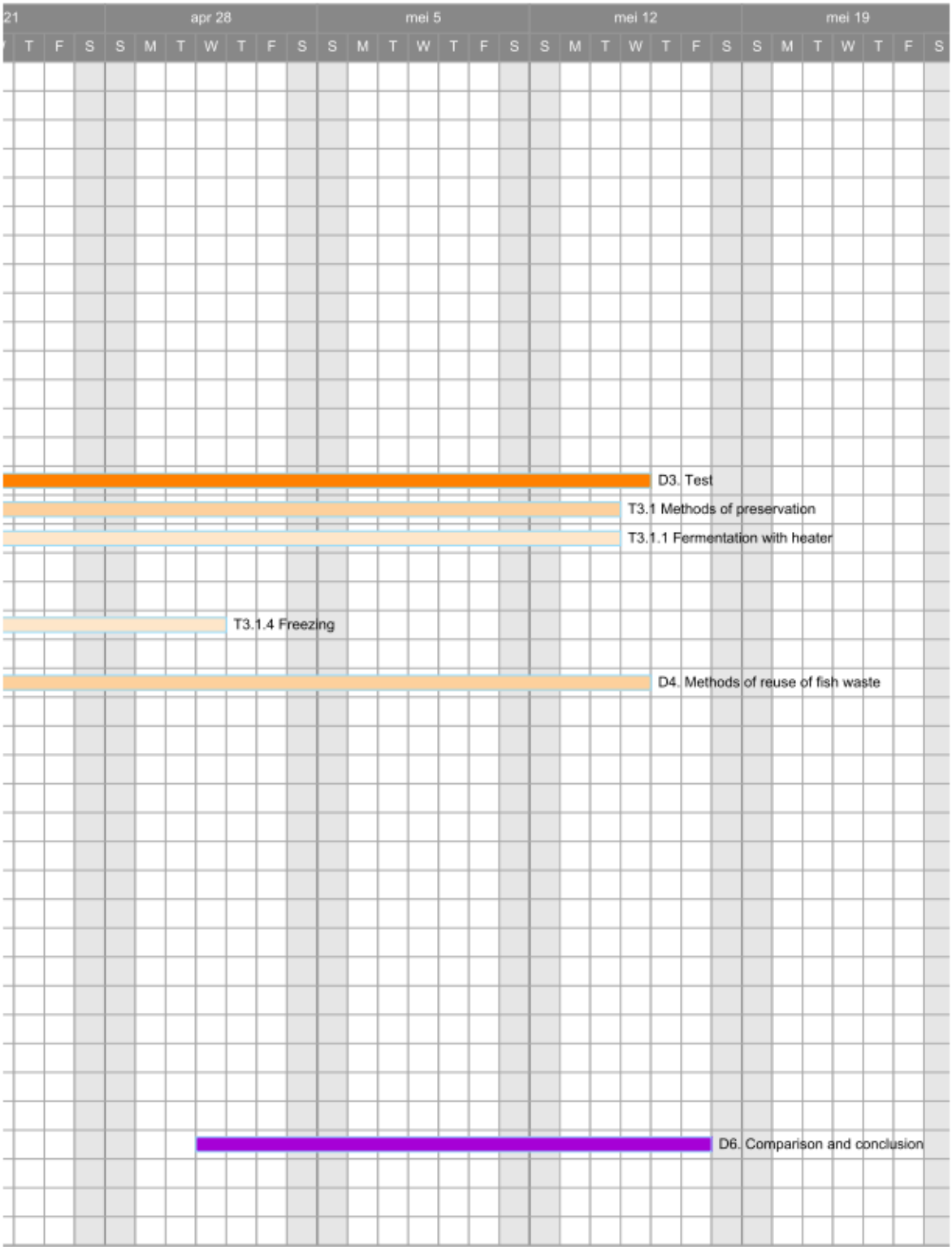

Name: The Fishers
Date: 6/03/2024
Fish waste Project
D1.Research
T1.1 Preservation method
T1.2 Reuse of fish waste
T1.1.1 Choose 3 methods
D2. Fabricate
T2.1 How to do it
T2.2 design 3 stands
T2.3 Buy all items
T2.4 Manufacture the stands
T2.3.1 For fermentation
T2.3.2 For pickling
T2.3.3 For freezing
D3. Test
T3.1 Test Fermentation
T3.2 Test Pickling
T3.3 Test Freezing
T3.1.1 Go further with the working tests
D4. Values monitoring
T4.1 pH sensor
T4.2 Tempeture sensor
T4.3 CO2 sensor
T4.1.1 Collect all the data
D5. Comparison and conclusion
T5.1 Most advantageous method
T5.2 Most cheapest/ profitable method
T5.1.1 Conclusion most advantageous
T5.2.1 Conclusion most cheapest and profitable

10.4 Project Scheduler

Tasks	Assigned To	feb 11							feb 18				
		S	M	T	W	T	F	S	S	M	T	W	T
D1. Research													
T1.1 Preservation methods	everyone												
T1.2 Reuse of fish waste	everyone												
D2. Fabricate	everyone												
T2.1 How to do it ?	everyone												
T2.2 List of materials to be bought	Quentin												
T2.2.1 Design proces of fermentation	Nora												
T2.2.2 Design pickling proces	Nora												
T2.2.3 Design freezing proces	Nora												
T2.3 Buy stuf	everyone												
T2.3.1 Manufacturing fermentation	everyone												
T2.3.2 Manufacturing pickling test	everyone												
T2.3.3 Manufacturing freezing test	everyone												
D3. Test	everyone												
T3.1 Methods of preservation	everyone												
T3.1.1 Fermentation with heater	everyone												
T3.1.2 Pickling	Timothy												
T3.1.3 Pickling + Freezing	Fayaad												
T3.1.4 Freezing	Fayaad												
T3.1.5 Others...													
D4. Methods of reuse of fish waste	everyone												
T4.1 Fish oil													
T4.2 Paper													
T4.3 Collagen													
T4.4 Gelatin													
T4.5 Bioplastic													
T4.6 Beauty products													
T4.7 Concrete with fish bones													
T4.8 Others...													
D5. Values monitoring	everyone												
T5.1 pH	everyone												
T5.2 Amount of CO2	everyone												
T5.3 Temperature	everyone												
T5.4 Duration of effectiveness	everyone												
T5.5 Others...													
D6. Comparison and conclusion	everyone												
T6.1 Most advantageous method													
T6.2 Chepeast method													
T6.3 Most profitable method													


feb 25
mrt 3
mrt 10
mrt 17
D1. Research
T1.1 Preservation methods
T1.2 Reuse of fish waste
T2.1 How to do it ?
T2.2 List of materials to be bought
T2.2.1 Design proces of fermentation
T2.2.2 Design pickling proces
T2.2.3 Design freezing proces
T2.3 B
T2.3.1
D5. Values monitoring
T5.1 pH
T5.2 Amount of CO2
T5.3 Temperature
T5.4 Duration of effective


mrt 24
mrt 31
apr 7
apr 14
S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W
D2. Fabricate
uy stuf
Manufacturing fermentation
T2.3.2 Manufacturing pickling test
T2.3.3 Manufacturing freezing test
T3.1.2 Pickling
T3.1.3 Pickling + Freezing
ness


21
apr 28
mei 5
mei 12
mei 19
T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S
D3. Test
T3.1 Methods of preservation
T3.1.1 Fermentation with heater
T3.1.4 Freezing
D4. Methods of reuse of fish waste
D6. Comparison and conclusion

10.5 Code of conduct

Code of conduct

The Fishers

Team members:

- Nora Brugada
- Quentin Rames
- Fayaad Babs-Khalid
- Timothy Mous

Team rules:

1. Everyone in the team respects each others idea and listens.
2. Every critic given by a team member will be handeled constructive and helpful.
3. The team will do a meeting atleast once a week.
4. The team will do a meeting atleast once a week with the teacher present.
5. The team always looks for the best result/outcome for the project.
6. Decisions will be made by voting: majority vote wins.
7. Team members will fill in their agenda of what and when they worked on the project.
8. The team leader will make a TO DO list before every meeting and send this to Mikael.
9. Team members will add their own questions to the TO DO list or ask the team leader to do this for them.
10. Everyone in the group is on time or atleast gives notice to the team if they'll be late or even cannot make it.
11. Everyone in the group respects the deadlines set and will complete it before.
12. The group secretary writes all of the information down that has been said in the meetings with or without the teacher present.
13. After the mid-term meeting the roles of secretary and leader switches.
14. Sanctions: If a group member is late to a meeting and didn't let anyone in the team know he has to bring coffee/ thee for everyone.

Signatures:

Nora: Quentin: Fayaad: Timothy: