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Abstract

Consuming food plays an important role in a person's quality of life. Dysphagia is a medical condition where chewing and swallowing are difficult, and this condition is most common among the elderly. It can lead to malnutrition, aspiration, low energy levels and reduced life quality. During the next ten years, the number of elderly persons is expected to increase and subsequently, the necessity for more personalised diets, particularly for persons with dysphagia. To prevent the risk of aspiration, texture-modified products with different texture levels have been requested in dysphagia management. In Norway, "Kostholdshåndboken" has categorised dysphagia food into 4 levels, while the International Dysphagia Diet Standardisation Initiative (IDDSI) have suggested a framework for foods and liquids into 8 levels. The municipal age-care kitchen (Sandnes Matservice) currently produces texture-modified products that are not categorised, but they want these products to be used as a reference and to gain knowledge for the production of a softer level aimed for patients with severe dysphagia (IDDSI level 4 – "pureed").

We developed a total of 9 recipes with salmon as raw material, added combinations of oil, water and the texture modifiers Agar and modified corn starch (Farinex). The preliminary experiments were conducted with Heat Treatment (90 ^{o}C for 35 min) or High-Pressure Processing (400 or 600MPa). These products were stored chilled (4 ^{o}C) and tested for microorganisms (total viable counts) at day 1 and day 21 and for texture and colour measurements. After the preliminary recipes, 7 new recipes were produced, adjusted with more liquids and less salmon to obtain a softer product. The adjusted products received heat treatment (90 ^{o}C for 35 min) and freezing (-30 ^{o}C) and were measured in terms of texture, colour, rheology and a Spoon Tilt Test developed by IDDSI.

The microbiological analysis showed low numbers (< log 3 cfu/g) and minimal growth of microorganisms from day 1 to day 21 for both heat-treated and high-pressure processed products. The Farinex products had low hardness (N) values, higher yield stress, higher storage modulus, a higher viscosity (at 1/10 1/s) and a tan delta under 0.6. These values indicate a product safer for swallowing than the control sample and the Agar products produced in this project, thus concluding that the Farinex product was the most adequate in a dysphagia diet. The Agar products showed a low yield stress and lower viscosity levels. This could mean that the product is more liquid, indicating that the product is less adequate than the Farinex products. From these results, it was concluded that the desired texture, IDDSI level 4 - pureed food, was achieved for the adjusted products.

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I would also like to thank Sandnes Matservice for providing their products which were a suitable control sample for this thesis.

My supervisors taught me more than I could imagine, and this is knowledge I will bring with me in the future. I would like to thank Nofima for their collaboration and interest in my work.

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Abbreviations

A	Agar
ANOVA	Analysis of Variance
CIE	Comission Internationale de l'Eclairage
F	Farinex
FT	Frozen Treatment
HPP	High-Pressure Processing
HT	Heat Treatment
IDDSI	International Dysphagia Diet Standardisation Initiative
LVR	Linear Viscoelastic Region
MA	Mixed Agar
MF	Mixed Farinex
PCA	Plate Count Agar
PN	Personalised Nutrition
TMF	Texture Modified Food
TMP	Texture Modified Product

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1 Introduction

The average number of people over 65 has been increasing gradually in recent years and is predicted to increase further in the next decade. The health of elderly adults is greatly influenced by proper nutrition. Over the past decade, healthcare systems have shifted from a solely treatment-based focus towards a more personalised, person-centred, and prevention-oriented approach. Humans in different parts of their life have changing nutritional demands at individual and group/population levels. The research on "personalised nutrition" has grown exponentially throughout the years (Ueland et al., 2020).

Personalising food can be challenging, as the term has not been clearly outlined, and an accurate definition of "personalised nutrition" (PN) has not been developed. In general, the word PN refers to the understanding that one size does not fit all because of variances in biochemistry, metabolism, genetics, and microbiome, among other factors (Bush et al., 2020). PN is created using dietary recommendations that address unique biological needs based on a person's health and goals (van Ommen et al., 2017). Public health recommendations are often based on preventing food-related chronic diseases. There has also been increasing recognition that genes involved in critical metabolic pathways can be affected by an individual's diet and environment (Laddu & Hauser, 2019)

Changes associated with ageing impact food texture choices for healthy elders and those used therapeutically for people with swallowing difficulties (dysphagia). Many factors are important in personalising foods for the elderly. These are texture and rheological factors, colour, cohesiveness and nutritional values. The manipulation of texture has been studied and tested for years. Many researchers have incorporated and tested different texture modifiers – hydrocolloids to study how these influence texture, cohesiveness and colour.

Nutrient calculations are often performed when designing foods for the elderly. A high protein content is desired in many personalised foods. Protein is a macronutrient essential in maintaining muscle mass, reduces cholesterol and aids in healthy blood pressure.
The desire to design protein-rich foods in dysphagia management has increased as it helps to reduce the risk of sarcopenia (Ueland et al., 2020). Another important nutritional factor is its

high energy content. High energy content can reduce the chances of malnutrition and can lead to overall higher energy levels.

Nofima is a food research institute that does research and development on aquatic -, fish - and food nutrition. In Nofima, personalised nutrition is one of many strategic research areas within this institute. In Nofima, personalised nutrition is described as food designed to meet the specific demands of certain consumer groups, such as protein enrichment for the elderly. As the ageing population grows, Nofima has shown interest in researching and designing personalised foods that can help manage dysphagia in the elderly. Preparing dysphagia-friendly food is crucial for preventing infections and malnutrition and ensuring the safety of the elderly, who should be able to eat without fear of aspiration. This can lead to increased appetite and increased quality of life.

The main aim of this thesis was to produce products that would be adequate for dysphagia patients. Sandnes Matservice is a municipal age-care kitchen that provides patients with dysphagia with customised food. The kitchen could only make one undefined texture-modified food and wanted the information and help to develop a soft product for patients with the most severe dysphagia. Designing personalised food requires in-depth knowledge, time and research (Ueland et al., 2020). In researching and developing dysphagia customised food, advanced technologies are needed to measure the textural and rheological aspects of the products. This work includes processing technologies such as traditional heat treatment but also innovative high-pressure processing in combination with either freezing or cold storage of the products. IDDSI – The International Dysphagia Diet Standardisation Initiative has focused on an international categorisation of foods in different levels (0-8). This framework has developed simple measurement methods for texture levels that can be used by anyone, people with dysphagia, caregivers, clinical, food services or industry (*The IDDSI Framework*, 2019).
The objective of this work was to develop texture-modified salmon products in category 4 of the IDDSI framework (puree) and to document the necessary recipes, processing and storage conditions that can be used.

2 Theory

2.1 Anatomy and physiology of normal and abnormal swallowing

Eating and drinking are essential factors that if impaired, can negatively impact an individual's quality of life. Swallowing plays an important role in a person's enjoyment of food. The swallowing process is complex as it involves over 30 nerves and muscles. The most crucial features of these muscles include the passage of food from the oral cavity to the stomach and airway protection (Matsuo & Palmer, 2008).

Swallowing takes several steps. As shown in Figure 1, food must be chewed and formed into a bolus for the tongue to guide it through the throat into the oesophagus but not allow leakage into the airways (larynx). Liquids are held within the mouth before being swallowed. Swallowing requires the coordination of multiple muscles regulated by swallowing centres in the brain but can also be influenced by brain centres with voluntary control. Therefore, the process is partly automatic and partly conscious (Sasegbon & Hamdy, 2017). Certain groups in society have issues with chewing and swallowing. Those can be humans with diseases, such as cancer, or the elderly who experience increased chewing problems as they age.

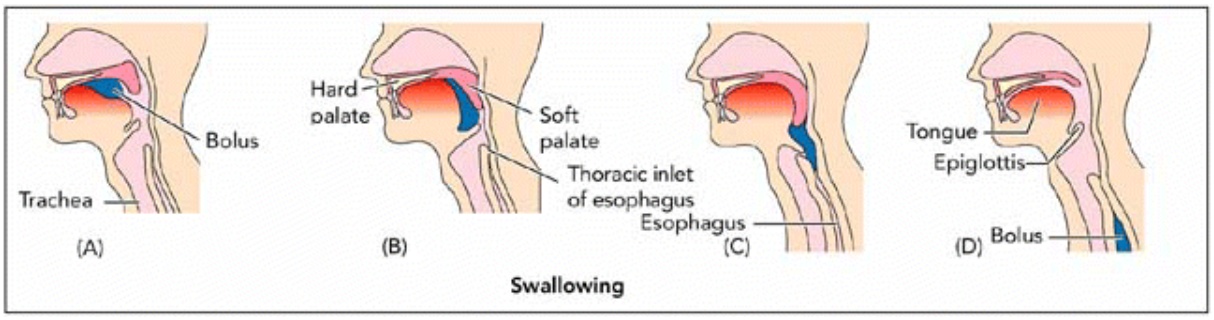

Figure 1. The swallowing process is described in four phases: forming a bolus in the mouth and transporting it down to the bolus. Copied from: (Wysong, 2007)

2.1.1 Dysphagia Food and challenges related to Dysphagia

Approximately 8% of the world's population suffers from dysphagia, but among the elderly, dysphagia is much more common (Giura et al., 2021). Dysphagia is a diagnosis given to patients with the worst impairment in chewing and swallowing. This condition is a symptom of various health conditions, such as respiratory, nervous, muscular, and digestive disorders.

Patients with dysphagia might have trouble eating solid foods and drinking liquids, which can lead to choking and aspiration (Cote et al., 2019).

Choking occurs when the airway is blocked by food, drink, or foreign objects, while aspiration occurs when food or liquids are breathed through the lungs, entering the trachea instead of the esophagus. Dysphagia can cause reduced oral intake, leading to weight loss, malnutrition, dehydration, extended hospitalisation, weakness, illness, and lower survival rates (Dick et al., 2020; Giura et al., 2021)

Despite the desire to put patients on a diet more suitable for dysphagia, this diet can also lead to challenges. These challenges include patients experiencing 17-37% lower energy levels than patients on regular diets (Dick et al., 2021).
As a result of dysphagia, it has become critical for patients to ingest texture-modified foods (TMF). Texture-modified foods lead to easier swallowing and reduced risk of choking (Giura et al., 2021). TMF includes “regular” foods modified to be pureed, minced, or have a jelly-like texture by adding flow enhancers, such as Tapioca starch, Corn starch and Agar.

The texture-modified food needs to be easy to swallow and prevent choking. It is also critical to design TMF that prevents food-borne diseases when stored in chilled conditions, as dysphagia patients are more susceptible to illnesses due to a compromised immune system. It is also essential that the texture-modified food is appealing, thus increasing the acceptability and appetite of dysphagic patients (Merino et al., 2020).

Many methods have been developed to measure and categorise the texture and thickness of liquids and foods for dysphagia management. Some methods include technologies that gather information about textural and rheological properties. These include shear viscosity, yield stress, hardness, cohesiveness, and adhesiveness. High-pressure processing (HPP) and 3D food printing are also methods used to modify dysphagia's texture characteristics. These methods are essential to preserving the safety and nutritional value of the dysphagia foods (Giura et al., 2021).

2.2 Raw materials and ingredients in a texture-modified product

Dysphagia management should ensure that the texture-modified product is easy to swallow and nutritious. Many different factors can contribute to an adequate dysphagia diet. Food is a good source as it contains essential macro – and micronutrients crucial for humans (Ueland et al., 2020). Particular nutritional demands arise during age, significantly affecting the amount and type of foods produced for older consumers. Thus, texture-modified foods have soft textures, reduced particle size, and thickened liquids (drinks) (Aguilera & Park, 2016).

Soft and moist food with soft textures is advised for the elderly. Fibrous starches and sticky and adhesive textures should be avoided (Cichero et al., 2016). Soft-textured food is preferable because it is dissolved and combined in the mouth by tongue-palate compression, avoiding teeth mastication (Ishihara et al., 2013).

Raw materials are essential in modifying food as they can be treated and used in various ways to address personal dietary needs. A protein-rich diet is crucial for the elderly and dysphagia patients as they are often at risk of loss in muscle mass and strength and decreased bone density. When creating foods for personalisation, a sufficient intake of easily digestible protein is crucial (Ueland et al., 2020).

It has also been found that texture-modified diets are lower in nutrients and have a lower energy and protein content than a regular diet (Shimizu et al., 2018). Dysphagia and malnutrition have been closely linked together, as 39.2% (Ueshima et al., 2021) of dysphagic patients are at risk of malnutrition since dysphagic patients only meet 45% of their energy requirements (Ueshima et al., 2021; Wright et al., 2005).

2.2.1 Hydrocolloids

Hydrocolloids are long-chained polymers of polysaccharides and proteins that, together with water, can form a gel. Their large number of hydroxyl (-OH) groups increases their possibility of binding to water molecules. Some of the most used hydrocolloids are starches, xanthan, guar gum, agar, pectin and gelatin (Saha & Bhattacharya, 2010). Hydrocolloids are often used in foods because they increase the viscosity (Herawati, 2019). The hydrocolloids used in this study was Agar (Appendix A) and Farinex (Appendix B).

Agar

The point of gum-based thickener types, such as Agar, is that they have a lot of general properties which can help to produce the required texture and improve rheological properties through the formation of three-dimensional properties. Gum-based thickeners are hydrocolloidal polysaccharides that exhibit good binding properties with water and other materials (Giura et al., 2021). Thickened foods with gum-based thickeners, such as Agar, will have a soft, uniform texture, and optimised taste, will not be affected by amylase and will not only be stable over time but also stable over a range of temperatures and pH levels. Another benefit of Agar is the ability to form thicker fluids which provide lower oropharyngeal residues at lower concentrations than starches (Chakraborty et al., 2022; Suebsaen et al., 2019).

Modified Corn Starch

Modified corn starch is a food additive often used as a stabiliser and thickening agent. Starches are biodegradable, hydrophilic polymeric carbohydrates derived from plants. Amylose (15-30%) and amylopectin (70-85%) are two polysaccharide components in starch. Amylose is a linear chain of alpha-1,4-glycosidic linkages, linked together by alpha-1,6-glycosidic linkages of the amylopectin (Chakraborty et al., 2022). Corn starch, in the "regular" form, lacks characteristics such as low thermal stability, slight resistance to shear force, and a high tendency to retrograde (Marta et al., 2022). Corn starch has therefore been chemically modified to increase the shelf-life of food products and water-holding capacity, leading to a more gel-like structure and excellent storage stability (Fu & BeMiller, 2017)

2.2.2 Other raw materials and ingredients

Salmon

Salmon is a great source of protein, lipids, vitamins, minerals, and essential nutrients. Salmon has long been an important food source due to its high fatty acid content and high fat and protein composition. Fats have a higher caloric content among the macronutrients (Rios et al.,

2014). Salmon was used in this project to help prevent malnutrition in people suffering from dysphagia and increase the caloric and protein intake for the elderly.

Oil

Lipids are a diverse group of substances that do not easily dissolve in water but easily in fat solvents. Oils are a group of lipids mainly made up of triglycerides (Rios et al., 2014). Oil increases the caloric content of food and has been thought to influence the functional and sensory properties of foods significantly. Any slight change in the oil content alters the physical-chemical properties and can affect the appearance, flavour characteristics, textural properties and shelf life (Wang et al., 2021).

Water

Water is essential for all life. It has chemical and physical properties that are necessary for all cells and organisms. In this study, water was used for two primary purposes. Foods containing more water can help living organisms (such as humans) ingest enough water, thus decreasing dehydration. Water is also a medium needed to control reactions, food texture and physical and biological behaviour. The hydrogen bonds in water play the most significant role in determining the structure and properties of water and food components. The characteristics of water are a crucial parameter of foods, as water affects texture, taste, appearance, safety, and shelf life (Kasaai, 2014).

2.3 Food safety

Fresh salmon fillets were used as raw materials for the texture-modified products. Microorganisms are found in high numbers on the surfaces of fish, such as the skin, fish gills and in the gut. Outbreak reports show microbial pathogens such as bacteria, viruses and parasites to cause disease when consuming raw or uncooked fish. Environmental aspects also play a crucial role because storage, transportation, hygiene and how a person handles the fish can cause uncertainties related to the safety of the product (Vergis et al., 2021).
Therefore, food safety and quality are essential when using raw fish materials in recipes for products with a given shelf life in chilled storage. Seafood products are sensitive to processing technologies due to their chemical composition, and they are highly perishable, especially when mildly processed (Cheng et al., 2014). The choice of processing technology is essential, as preservation methods (such as high temperature) can reduce quality and nutritional value.

Because of these adverse effects of thermal processing, many researchers are now testing novel non-thermal technologies (NTTs). One example of the NTT method used in this study was High-Pressure Processing (HPP) (Rathod et al., 2022). Applying HPP at 100-600 MPa is proven to inactivate multiple microorganisms, spores and enzymes in food, leading to increased shelf life (Balakrishna et al., 2020).

2.3.1 Microbiology

Food safety requires continuous monitoring of food pollutants and identification of risk factors (Suzzi & Corsetti, 2020). The growth and activity of pathogens in food can cause foodborne illness when consumed. Knowledge of the content, origin, pH, water activity, and storage conditions of food, as well as the features of the most frequent and resistant bacteria, can help predict microflora composition throughout processing and storage (Lorenzo et al., 2018).

Microbial infection occurs because of the presence and multiplication of bacteria. Microorganisms' ability to grow in food, pharmaceutical and cosmetic products has been identified for many years. The bacteria can release substances that change the food properties or change them into toxic substances. Microbial toxins cause diarrhoea, acute gastroenteritis, and abdominal discomfort. Symptoms like these can vary from mild distress to stomach death, all depending on the individual's sensitivity to toxins (Nemati et al., 2016). Few products for dysphagia patients are available as chilled products. Since this is a vulnerable group, often with a weakened immune system, there is a special need to ensure that the products have excellent microbiological quality throughout the shelf life.

2.3.2 High-Pressure Processing

Consumers increasingly demand convenience meals of the greatest quality in terms of natural flavour and taste, as well as those devoid of additives and preservatives. This demand led to the development of several non-thermal ways of food processing, where high-pressure technology is useful (Rastogi et al., 2007). Microorganisms and their spores are eliminated during high-pressure processing depending on the intensity of the process parameters. HPP is beneficial as it is used instead of thermal treatment and chemical preservatives. HPP has a small effect on low-molecular-weight compounds, such as flavour compounds, vitamins, and

pigments, compared to thermal processes. This ensures that the nutrients, flavour and nutrients are preserved within the food (Muntean et al., 2016).
Regarding nutritional value, colour, and other sensorial attributes, HPP can retain food quality better than heat treatment (Agregán et al., 2021). The use of HPP has gathered a big interest in personalised foods. Dysphagia products are carefully designed and treated with HPP to ensure the retention of nutrients and the absence and growth of microorganisms.

Depending on the strength of the treatment, pressure treatment with or without heat might result in pasteurisation or sterilisation of food products. Minimal influences on product chemistry result from pressure treatment at ambient temperatures and are used to pasteurise foods. The application of pressure decreases the need for high thermal exposure of the products during processing, thereby protecting a variety of bioactive compounds (Balasubramaniam et al., 2015).

2.4 IDDSI - The International Dysphagia Diet Standardization Initiative

The International Dysphagia Diet Standardization Initiative (IDDSI) is an international framework categorising texture-modified food and drinks into 8 levels (0-7). Level 0-4 for drinks and 3-7 for food (Figure 2) (Dick et al., 2020). The IDDSI framework aims to develop a global standardised terminology and definition for texture-modified foods and liquids for patients with dysphagia of all ages, in care settings, and for all cultures (Cichero et al., 2016; The IDDSI Framework, 2019). Different methods are proposed to measure and categorise thickened liquids/foods for dysphagia management.

Many age-care facilities have similar meal preparation procedures, in which pre-cooked texture-modified food is refrigerated or frozen and subsequently re-heated so it can later be served at an adequate temperature. Texture measurement can be challenging for patients living at home or employees preparing food at age-care facilities as more advanced testing methods are less available. For this reason, IDDSI has developed different simple and practical methods to test and categorise the texture of food into different texture levels. These IDDSI methods use basic tools, such as a 10 ml syringe, spoon, chopsticks, or fingers (Dick et al., 2020). This thesis focused on foods in level 4 (pureed), often determined by the Spoon Tilt Test. This test examines if the food is cohesive enough to hold its shape on the spoon

when tilted. The sample tested should be cohesive enough to hold its shape on the spoon and plop off it after a gentle flick (some food can remain on the spoon).
Some characteristics of level 4 (pureed foods) are usually food that is not sticky with no lumps, does not require chewing, and cannot be sucked through a straw. The aim is also to obtain a texture that cannot be drunk from a cup and will not flow easily (*The IDDSI Framework*, 2019).

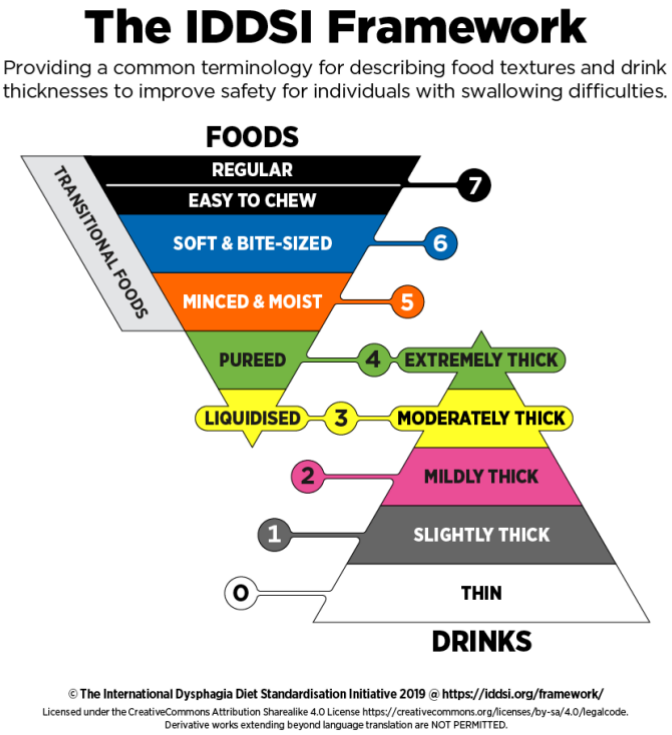

Figure 2. The different food textures and drink thickness levels categorised by IDDSI (The IDDSI Framework, 2019)

2.5 Important biotechnology for measurements

2.5.1 Texture measurement

According to Bourne, food's four principal quality factors include appearance, flavour, texture, and nutrition (Bourne, 2002). The texture is defined by physical properties such as adhesiveness, cohesiveness, firmness, hardness, springiness, viscosity, and yield stress. These are considered significant texture components in dysphagia management (Kwak et al., 2021). A texture measurement is essential as it describes different aspects of the food product,

including structural and rheological properties. It is one of the most essential qualities in food, as it defines the quality and acceptability of the product (Raheem et al., 2021).

A product can have a soft texture when newly produced and when at an average eating temperature of about 50-60 ^{o}C. However, it becomes harder as the dysphagia patient eats and the food temperature decreases. In the analysis, the texture is measured as hardness with units in Newton (N), describing the maximum force required to compress the food to a given deformation (Kwak et al., 2021). A texture analyser will also show hardness and adhesiveness through a compression test. Adhesiveness shows the work required to remove food from the mouth (palatal) during normal swallowing (Giura et al., 2021).

For semi-solid meat products with modified textures, such as pureed meat products, the hardness values should be between 0.70-4.60 N, and cohesiveness values between 0.15-0.45 N, as shown in Table 1 (Dufresne & Germain, 2009).

Table 1. Textural values of pureed meat and minced meat products in Newton (N) for hardness and cohesiveness (Dufresne & Germain, 2009).

	Hardness (N)	**Cohesiveness (N)**
Pureed meat products (IDDSI level 4)	0.70-4.60 N	0.15-0.45 N
Minced meat products (IDDSI level 5)	1-11 N	0.10-0.38 N

2.5.2 Colour measurement

Colour is an important food quality as it influences consumers' choices and preferences. The appearance of food is essential because it decreases or increases the appetite in dysphagia patients. Food appearance, determined mostly by surface colour, is the consumer's first impression and can affect whether the consumer chooses the product (Pathare et al., 2013). For this thesis, CIELAB was used to determine the colour quality of the texture-modified product. CIELAB expresses a colour's lightness, red/green intensity, and yellow/blue intensity. These are represented as values called L*a*b on a three-dimensional axis. (Figure 3). The L* axis represents the level of pigmentation and is shown as a greyscale with the values 0 (black) to 100 (white). The a* axis is a red/green axis, showing positive or negative

values of red or green values. The b* is the yellow/blue axis that also shows pigmentation. This negative or positive axis shows blue or yellow values (Ly et al., 2020).

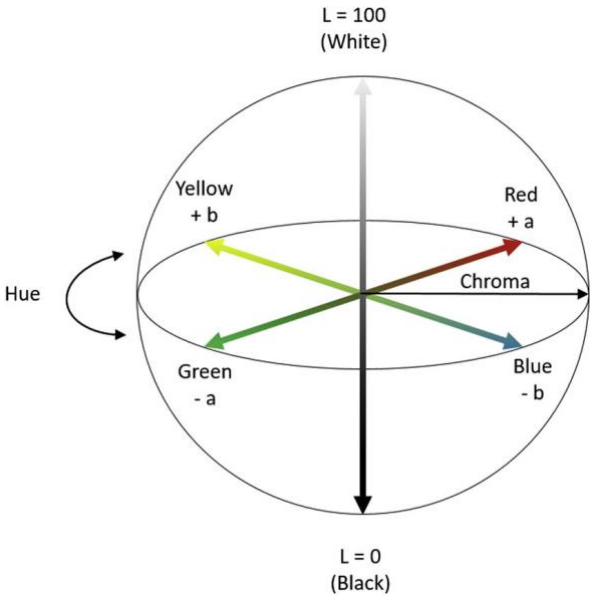

Figure 3. The CIELAB colour space diagram, including the three-dimensional axis of L*a*b (Ly et al., 2020).

2.5.3 Rheology

Rheology studies how materials deform due to stress or force (Janmey & Schliwa, 2008). When designing dysphagia-friendly food, the rheological properties of the products are essential to assess swallowing safety by measuring the viscoelastic and flow properties of the products.

In the following sections, the viscoelastic properties of the products can be assessed by performing dynamic oscillatory tests, called Amplitude and Frequency sweeps. In Amplitude Sweep, the material's response to increased deformation at a constant frequency is measured. This test provides information about the deformation that causes the inner structure of a certain material to soften, flow, or break down and determines the Linear Viscoelastic Region (LVR) (Dabbaghi et al., 2021).

An Amplitude Sweep can be used to measure the sample's storage and loss modulus (G'; G''), yield stress (Pa) and flow point (Stojkov et al., 2021). Yield stress represents the least stress required to cause a fluid to flow, but it also provides information about the strength of

the structure in more concentrated products. Greater flexibility and elasticity are associated with higher yield stress. Storage and loss modulus (G', G'') give information about the stiffness of the sample. Flow point is defined as the point where the product starts behaving like a liquid and G'=G''.
A Frequency sweep is used to measure the time-dependent behaviour of a product by varying the frequency of applied stress over time. By performing frequency sweeps, products can be further classified as viscoelastic liquids, solids or gels by looking at parameters such as tan δ, storage (G') and loss modulus (G'') (Stojkov et al., 2021). G' higher and parallel to G'' and tan δ value below indicates a weak gel structure which makes the product adequate for dysphagia patients. This means the product is safe to swallow without risking aspiration (Giura et al., 2023; Giura et al., 2021).

Flow properties of the sample are assessed by performing a continuous share rate ramp. This measures the product's viscosity at different shear rates. Shear rates are thought to range from 1 to 1000 1/s during the swallowing process. It has been suggested that apparent viscosities at shear rates of 1, 10, 30, 50, and 100 1/s would give a generally solid basis for comparing thickened fluids for dysphagia (Ross et al., 2019).
Viscosity at a shear rate of 1.0 1/s differentiates high and low-viscosity foods (Wendin et al., 2010). The higher viscosity of food provides individuals time to prepare food bolus while protecting the food from entering the airways. A thicker bolus is easier to swallow than a liquid bolus (Hanson et al., 2012). This reduces the risk of aspiration and choking (Abu Zarim et al., 2018).

For meat products to be categorised into a pate, timbale and jellied texture, rheological and textural parameters for hardness and storage modulus (G') are shown in Table 2. Rheological and textural parameters of pate, timbale and jellied textured food for hardness in Newton (N) and storage modulus (G') in Pascal (Pa) (Wendin et al., 2010)

Table 2. Rheological and textural parameters of pate, timbale and jellied textured food for hardness in Newton (N) and storage modulus (G') in Pascal (Pa) (Wendin et al., 2010).

Product	Hardness (N)	Storage Modulus (G', Pa)
Pate	0.60-2.50 N	11000-20000 Pa
Timbale/puree	0.50-0.80 N	15000-17000 Pa
Jellied meat	0.10-0.30 N	800-1600 Pa

3 Materials and methods

3.1 Workflow and Procedure for the TMP

This thesis aimed to produce a texture-modified product that followed levels 3 and 4 (Figure 2) of the IDDSI Guidelines. A variation of ingredients was used to achieve the desired texture of the product. A product with the right texture was achieved using heat treatment, high-pressure processing at 400 MPa and 600 MPa and freezing. Different texture modifiers, such as Agar and Farinex, were used with different amounts of water and oil. Colour, texture, rheology and IDDSI were used to describe the hardness, viscosity, cohesiveness and characteristics. Calculations of total protein content were used to check the nutritional level of the different recipes based on values from Matvaretabellen (2023) and datasheets from ingredient suppliers.

In this study, several steps were completed (Figure 4). The preliminary step included the production of the texture-modified product (TMP) and texture and colour measurements performed. Measuring the textual properties of the product was done using a Texture Analyser TA. XT Plus Texture Analyzer (Stable Micro Systems Ltd., Godalming, UK), a rheometer (Discovery HR-2, TA Instruments, US). The colour measurement was also performed using a program called DigiEye (DigiEye (VeriVide Ltd., UK) and a camera (Nikon, D90, AF, Nikkor 35 mm f/2D, Nikon Japan). Based on the data from the first measurement, the recipes were adjusted to help further achieve the desired texture. An IDDSI Spoon Tilt Test was also performed to see if the product was within the required range (levels 3 and 4) and give information about the cohesiveness of the product.

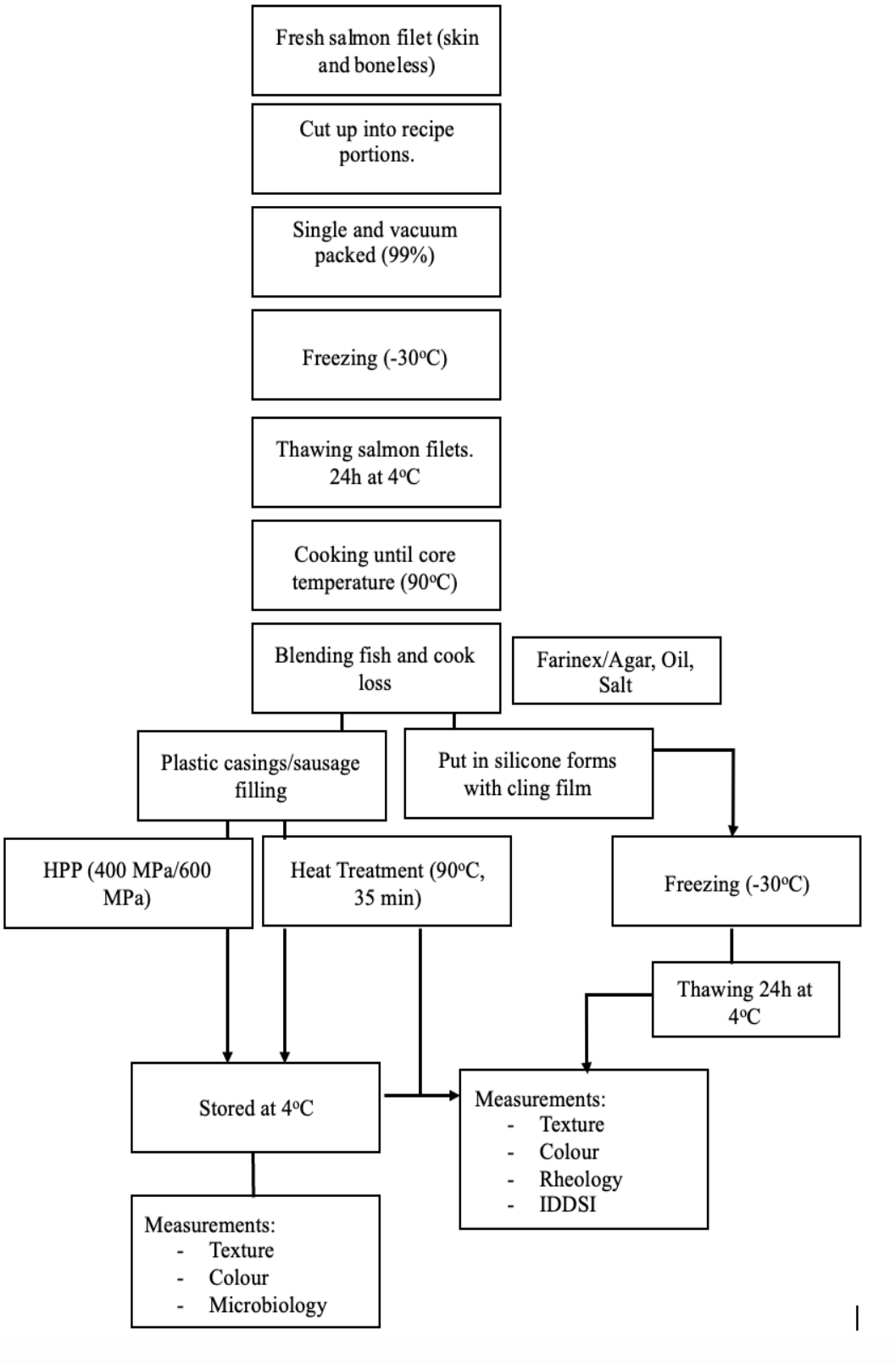

Figure 4. The production of the texture-modified products, including the different treatments and measurements performed.

3.2 Preparation of the fish

Skin – and boneless salmon was obtained from Domstein and prepared shortly after arrival. Filet-sized pieces (150-200g) were cut and weighted into the required portions (Table 4) and packed into plastic bags (250 x 300 mm, PA/PEK 20/50, Lietpack, Lithuania). The portions were then placed in a vacuum machine (Supermax C, Webomatic, Germany) at 99% vacuum and stored in a -30^{o}C freezer until further use.

3.2.1 Production of the preliminary product

The packed fish was removed from the freezer and thawed in a fridge (4^{o}C) the day before production of the recipe. The thawed fish was cooked in a preheated oven (MSCC61, Metos system Intl., Germany) at 95^{o}C and 100% steam. Temperature probes (Testo AG, 176T4, Germany) were put into the thickest part of the fish to check the core temperature. After reaching a core temperature of 90^{o}C, the fish was cooked for another 10 minutes. Immediately after cooking, the salmon, cooking loss was put into a thermomixer (Thermomixer, TM6, VorWerk). The rest of the ingredients were then put into the Thermomixer in a specific order and were mixed for a certain time with a mixing speed of 8 and 10 (Table 3). Mixing these ingredients was essential to ensure that the product got the desired texture and activation of the different ingredients.

Table 3. Order of the ingredients added into the mixer with mixing time (min. sec) and mixing speed (0-10).

Order	Ingredient	Mixing time (min.sec)	Mixing speed
1	Salmon, cook loss	01.30	10
2	Salt	00.15	8
3	Agar/Farinex	01.20	10
4	Oil	00.30	8

Table 4. Recipes 1 and 2 with the percentage of the ingredients, the two texture modifiers (Farinex and Agar) and calculated total protein content.

	Recipe 1	Recipe 2
Ingredient	**%**	**%**
Salmon	97.3	97.3
Salt	0.8	0.8
Oil	1.0	1.0
Farinex	1.0	-
Agar	-	1.0
Total protein content %	19.4	

The batch was then filled into a plastic casing (Betan, ART: 4210002500, Ø30 mm white, Viscofan, Czech Republic) using a sausage filler (Model 5 Litre De Luxe, Tre Spade, Italy) and closed with metal clips (SCH 120, Poly-clip System, Germany). The total product amount was divided into three similar parts to receive further treatment. One part was heated in a preheated oven (MSCC61, Metos system Intl., Germany) at 95^{o}C, 100% steam, for 35 minutes. The second and third parts were put into the High-Pressure Processing machine (QFP, 2L-700, Avure Technologies Inc., Columbus, USA). They were run at 400 MPa, and 600 MPa to increase the product's shelf life while keeping the necessary nutrients. The products were then stored at 4^{o}C until further use.

3.2.2 Texture measurement of the preliminary food sample

To measure if the products were suitable for people suffering from swallowing disabilities, a TA.XT Plus Texture Analyzer (Stable Micro Systems Ltd, Godalming, UK) was used. The Texture was measured with a penetration test measuring the force Newton (N) set with a cylinder probe (Delrin cylinder P/0.5 R). The texture analyser consisted of a 5 kg loading cell. The hardness of the preheated product was measured by putting it under the cylinder for a penetration test measured as force (N, Newton) set with a specific distance (20 mm).

Before starting the analysis, a calibration was performed, calibrating the weight (2000 g). The height was calibrated by zeroing the probe so it reached the base. To discover the maximum force, a list of macros was opened. The data was graphed, and the entire force, Newton (N), was diagrammed with the average value and standard deviation. While calibrating, three 1 cm slices of the product were cut up using a scalpel (Figure 5). The samples were put into a plastic container (HDPE-tray, RPC BEBO Food Packinging Norway), wrapped in a cling film (Global Plastics International, France) and warmed in a preheated oven (MSCC61, Metos system Intl., Germany) at 95ºC and 100%. The slices were warmed for 20 minutes, and the core temperature was checked to be 65-70ºC before performing the analysis. A small oven trolley (Termia 950H, Metos system Intl., Germany) was heated up to 75ºC and placed next to the texture analyser to keep the samples warm while the analysis occurred. In total, 6 parallels were conducted for each variant.

Figure 5. The samples were cut into 1 cm slices using a scalpel prior to the measurements

3.2.3 Colour measurement of the preliminary product

The same products used for the texture measurement were turned upside down to measure the colour using a camera, imagining cube and a system called DigiEye (VeriVide Ltd., UK). Before starting the measurement and calibration, the system was turned on for 15 minutes in advance for the light to warm up. The calibration was done using a white calibration board (DigiTizer Calibration Pack, VeriVide Ltd., UK) and setting the camera on “Manual Focus”. The calibration was then continued using a coloured calibration board with the camera set to “Auto Focus”. The calibration was complete when the table showed values of 115-125 (Figure 6). For the colour and brightness measurement, the product was put on paper, into a lightbox, and photographed by a camera (Nikon, D90, AF, Nikkor 35 mm f/2D, Nikon Japan). The photograph was then used to measure extractions of the colour L*a*b. The analysis of colour was done by marking a specific area in the product and copying the values into an Excel document for further analysis.

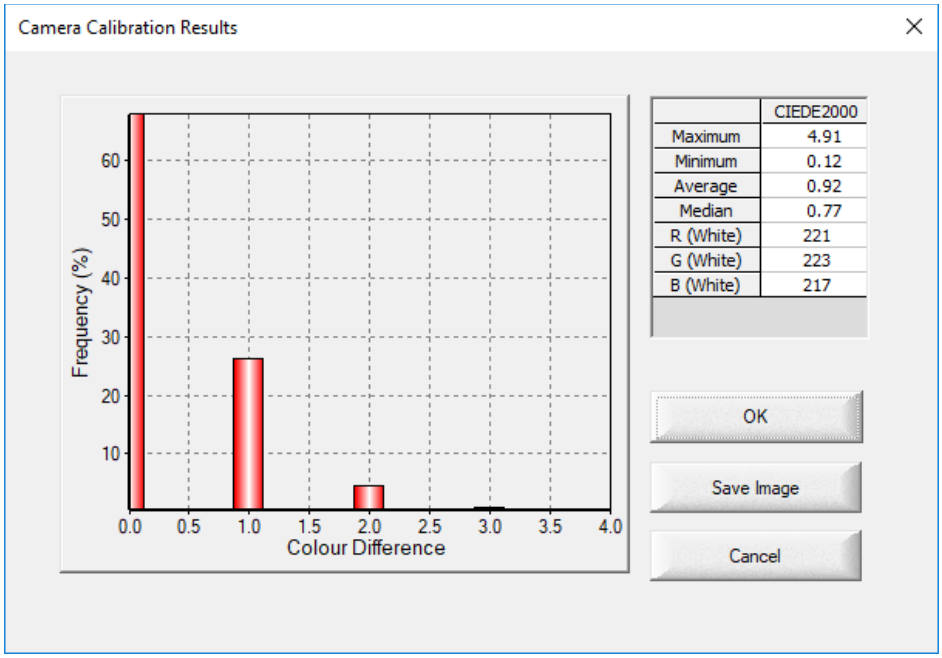

Figure 6. Calibration of the DigEye software and the camera connected. When the values at R,- G,- and B (White) are between 215-225, the calibration is successful. Values lower/higher than these indicate that the calibration needs to be performed again.

3.2.4 High-Pressure Processing

In addition to heating, recipes 1 and 2 received High-Pressure Processing (HPP). The same method was used to prepare the samples before the HPP (22). After preparation, the samples are immediately taken to the HPP machine (QFP, 2L-700, Avure Technologies Inc., Columbus, USA). HPP was conducted at 20ºC at 400 MPa and 600 MPa; both were pressurised for 2 minutes. After the treatment**,** the samples were stored at 4ºC.

3.2.5 Microbiology

One of the objectives was to develop a cold storage product (4 °C) with a shelf life of 3 weeks. To evaluate this, a 21-day microbiological shelf-life study was conducted on salmon products with recipes 1 and 2 stored at 4°C. Sampling was carried out initially the day after production and then, after 21 days, stored at 4 ºC.

A 25±2 g sample was removed aseptically from the centre of the product and transferred into a sterile lab blender bag (Separator 400, Grade Packaging Ltd, UK). The test sample was diluted to 1:10 proportion with 0,85% peptone salt diluent according to NMKL 91 (6th Ed.2010)

Figure 8 shows the sample after being homogenised for 120 seconds. The homogenised sample was homogenised for 120 secs in a SMASHER® homogeniser (AES blueline, bioMérieux, France) on a normal setting (560 strokes/min). 10 ml homogenate of each sample was collected in sterile tubes (PP, 15 ml, 17x118 mm, VWR, Norway). Each tube was used for aerobic plate count on plate count agar (PCA) (Figure 8).

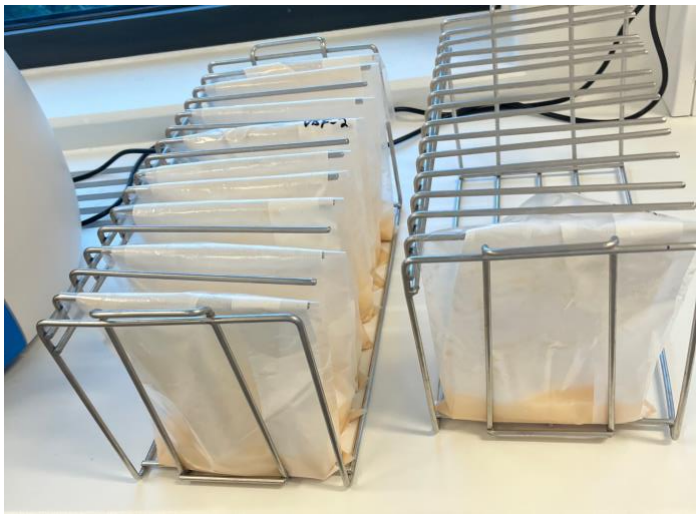

Figure 8. The sample after being homogenised for 120 seconds.

Figure 7. 1 shows the sample spread on a petri dish. 2 shows the automatic plater picking a sample from the sterile tube.

3.3 Adaptations to the recipe

During the production of the texture-modified product, 9 recipes were made. The aim was to find the specific textures within IDDSI levels 3 and 4 (Figure 2) and study how different texture modifiers react with specific amounts of fish, oil, and water. Samples were received from Sandnes Matservice – a municipal kitchen that produces and distributes food to 8 of the age-care facilities in this county.

The aim was to examine how their texture-modified products could fit with the levels of dysphagia patients. Table 5 shows the recipe for the products received from Sandnes Matservice. This recipe was used as a control sample in this study. Their recipe contained less fish (73.3%) than our preliminary recipe (97%). Our recipe contained more fish to obtain as high protein content as possible.

Table 5. The recipe of the control sample was received from Sandnes Matservice.

Ingredient	%
Salmon	73.3
Fish Broth	25.2
Agar	1.5
Total protein content %	14.6

Recipes 1 and 2 (preliminary recipes) were adjusted to create recipes 3-6. This was done by adding water to the recipe, reducing the fish to 75% (more similar to the control sample) and varying the total oil content in the recipes to obtain a texture at IDDSI levels 3 and 4 (Table 6). The production was the same as for the preliminary product (22), only changing HPP to frozen treatment (FT) to get a product processed closer to the control sample. The mixed product was divided into two parts. One part was put into the same sausage fillings to receive heat treatment (3.2.1 Production of the preliminary product, and the other part of the batch was put into silicone forms (Moul'flex, 6 tartelettes, SAS de Buyer Industries, France) to make a round puck product (Figure 9). The pucks were made even with a cake spatula. The tray of silicone form was wrapped with a cling film to be put into a freezer (-30^{o}C) until further use. The same procedure was repeated for recipes 7-9 (

Table 7. Recipes 7-9 with Agar and different oil and water contents for the adjusted TMP.

	Recipe 7	**Recipe 8**	**Recipe 9**
Ingredient	**%**	**%**	**%**
Salmon	75.0	75.0	75.0
Salt	0.8	0.8	0.8
Oil	0.0	2.0	3.0
Agar	1.0	1.0	1.0
Water	23.2	21.2	20.2
Total protein content %	14.9		

.

Table 6. Recipes 3-6 with Farinex and different oil and water contents for the adjusted TMP.

	Recipe 3	**Recipe 4**	**Recipe 5**	**Recipe 6**
Ingredient	**%**	**%**	**%**	**%**
Salmon	75.0	75.0	75.0	75.0
Salt	0.8	0.8	0.8	0.8
Oil	0.0	1.0	2.0	3.0
Farinex	1.0	1.0	1.0	1.0
Water	23.2	22.2	21.2	20.2
Total protein content %	14.9			

Table 7. Recipes 7-9 with Agar and different oil and water contents for the adjusted TMP.

	Recipe 7	**Recipe 8**	**Recipe 9**
Ingredient	**%**	**%**	**%**
Salmon	75.0	75.0	75.0
Salt	0.8	0.8	0.8
Oil	0.0	2.0	3.0
Agar	1.0	1.0	1.0
Water	23.2	21.2	20.2
Total protein content %	14.9		

Figure 9. The product is put into silicone forms before being wrapped in cling film and put into -30ºC for the frozen treatment (FT).

3.3.1 Texture measurement on the adjusted recipe

The same preparation and methods were done for texture measurement on the adjusted recipes (24**).** For the adjusted recipes, water was added together with the salmon and the cooking loss. The day before the texture analysis, the pucks were removed from the silicone forms (Moul'flex, 6 tartelettes, SAS de Buyer Industries, France) and single-packed using plastic bags (PA/PEK 20/50, Lietpack, Lithuania). The single-packed pucks were then vacuumed at 99% vacuum using a vacuum machine (Supermax C, Webomatic, Germany) (Figure 10. The pucks are single-packed in a plastic bag to be vacuumed before being stored at 4ºC for thawing..) The pucks were then stored at 4ºC to be fully thawed 18-24 hours before the analysis.

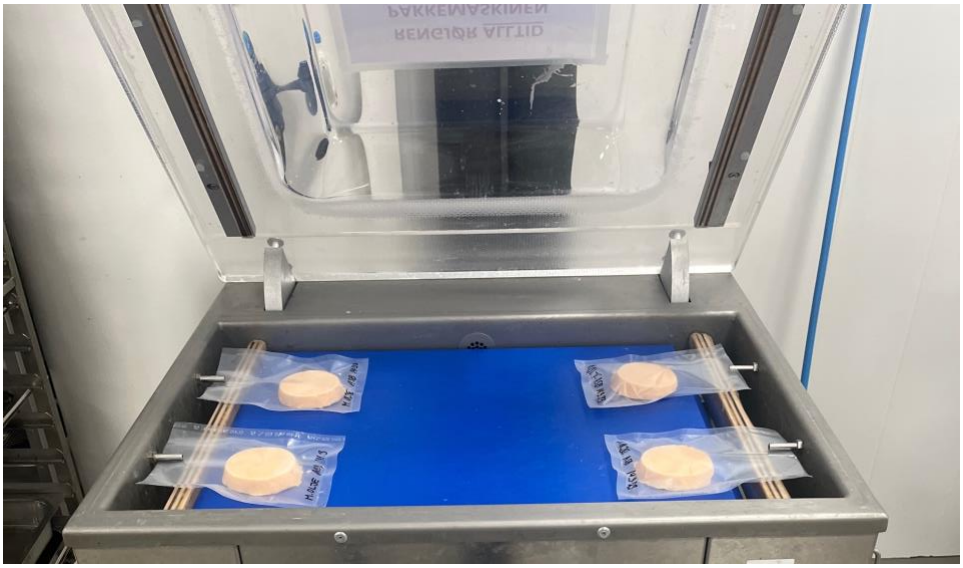

Figure 10. The pucks are single-packed in a plastic bag to be vacuumed before being stored at 4^{o}C for thawing.

3.3.2 Colour measurement on the adjusted recipe

The same preparation and methods were used for the adjusted recipes' colour measurements (25). The same method was also conducted for the frozen pucks (27) before the colour measurement.

3.3.3 Rheology measurement on the adjusted recipe

All Rheology measurements used Rheometer (Discovery HR-2, TA Instruments, US). All measurements were performed using crosshatched 20mm plate (XHATCH, 20 mm, Serial Number 111670, TA Instruments, UK), and a 40 mm crosshatch plate (Serial Number T170105, TA Instruments, US) with a Peltier system used to regulate temperature. All measurements were done at 60^{o}C and a gap of 1500 μm.

Before the rheology analysis, the heating and preparation of the product were the same as for the texture measurements (24).For rheology, only one sample was heated at a time. The sample was heated for 20 minutes, then mixed before putting it on the crosshatch plate. The sample was trimmed to fit the geometry plate before continuing the analysis. 28 measurements were done in total, with four parallels of each variant. This procedure was performed for Amplitude and Frequency sweep and again for Flow sweep.
Figure 11 shows the loading and trimming of the sample.

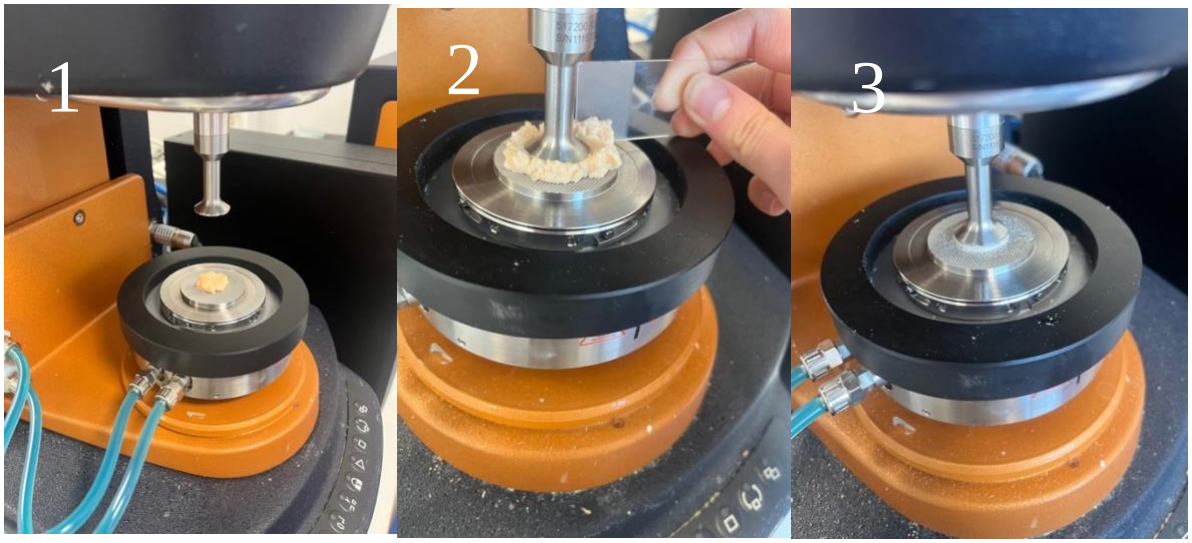

Figure 11. Loading and trimming of the sample on the rheometer. Picture 3 shows the finished result where the rheometer starts the analysis.

Amplitude Sweep

Amplitude Sweep was performed at a frequency of 1 Hz in which the strain range was 0,01-200%. This was performed to determine Linear Viscoelastic Region (LVR) and choose a strain in that range for further analysis and to get the Storage modulus, Yield stress and Yield strain at the end of LVR and Flow point. The point where G' value deviated 5% from the plateau value was taken as the end of LVR.

The different points registered are shown on Figure 12.

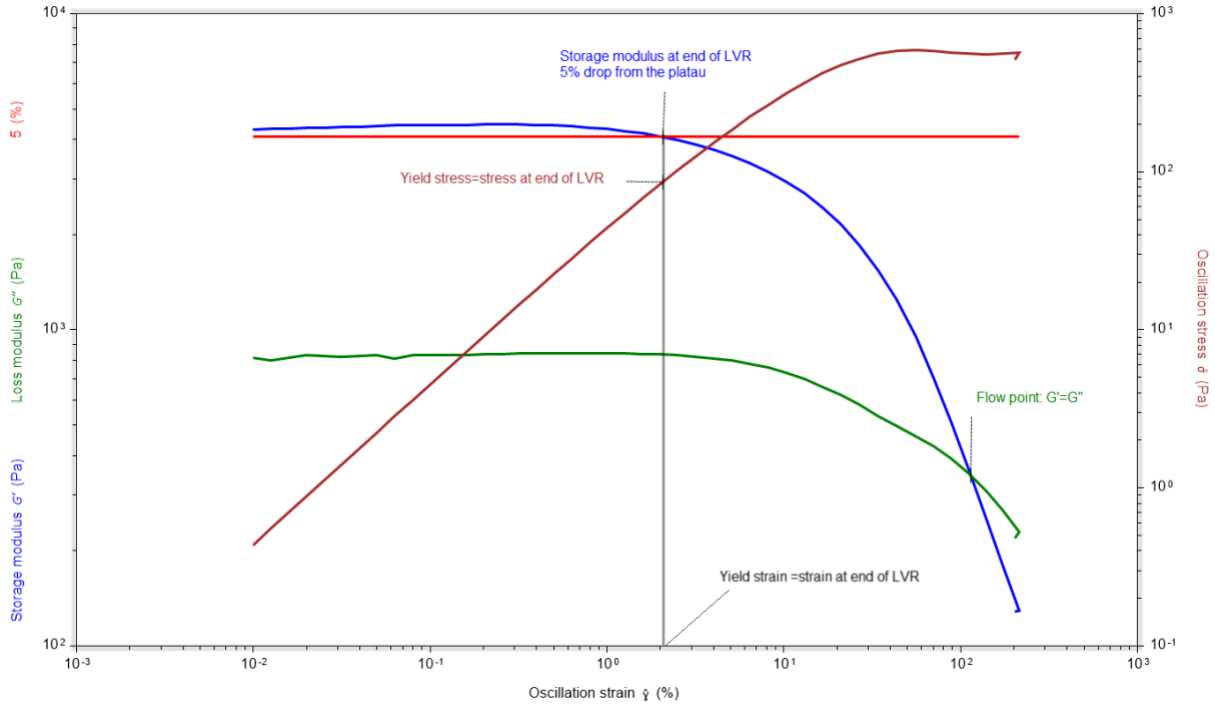

Figure 12. Illustration of data analysis and definition of points taken, made in Trios Software.

Frequency Sweep

Frequency Sweep was performed at a frequency of 10-0,01 Hz at a constant strain of 0,10% determined by amplitude sweep. Graphs were analysed, and values of G', G'' and tan δ at the frequency of 1Hz were obtained.

Flow Sweep

The Flow Sweep was performed at a shear rate of 0,0001-100,00 1/s. Results are further analysed in TRIOS software by doing the best-fit analysis, which showed that the Carreau-Yasuda model fitted best. Carreau-Yasuda model was fitted to all viscosity curves, and viscosity at 1 and 10 1/s was obtained.

3.3.4 IDDSI – Spoon Tilt Test

In age-care facilities, advanced technology might not be available for texture analysis. The IDDSI Framework has therefore conducted methods to test the textural aspects when other methods are unavailable. One of these methods is the Spoon Tilt Test.

The Spoon Tilt test was used to determine the adhesiveness and cohesiveness of the product. The same preparation and methods were done as before (15). 9 Spoon Tilts were done per variant. Before starting the Spoon Tilt Test, the core temperature was measured and written down to observe if the temperature changed the test result.

After the product was heated, a mouthful was placed on the spoon. The spoon was tilted gently using only the wrist and fingers (Figure 13. The IDDSI Spoon Tilt Test on a product containing 3% oil with frozen treatment (FT). The spoon was tilted for about 5 seconds, and the observed result was documented. The results were then counted (stayed on a spoon/fell off spoon), and a percentage was calculated, for how often the sample fell off the spoon.

Figure 13. The IDDSI Spoon Tilt Test on a product containing 3% oil with frozen treatment (FT).

3.4 Statistical Analysis

Data obtained from the measurements in this thesis were tested to get a better overview of possible significant differences. This was done using a one-way ANOVA in Minitab 19 Statistical Software (Minitab Ltd., UK, 2020). Tukey's Pairwise Comparison was conducted. The level of significance was determined at $p>0.05$.

4 Results and Discussions

The recipes created in the preliminary production were generated by combining data from nutritional calculations and texture analysis. The aim was to develop recipes for a texture-modified product with a soft, pureed texture that is easy to chew and swallow for people with dysphagia. These individuals suffer from low food intake and malnutrition; therefore, a nutrition calculation was performed to obtain a recipe with the highest possible protein content while maintaining the desired texture.

4.1 Measurements performed on the preliminary recipes and the control sample.

Sandnes Matservice provided products as a reference to what is usually made in their kitchen today. Their texture-modified product is already used for dysphagia management in age-care facilities. Still, they strongly desired to design an even softer product for patients with special demands and with the worst cases of dysphagia. It was therefore decided that their recipe would be used as a control sample to examine what modifications were needed to obtain a product that was softer in texture.

A total of 4 samples of the same salmon product from Sandnes Matservice were used as controls and tested. Texture, colour, and rheological measurements of the control sample were performed and compared with the end products from recipes 1 and 2, as shown in .

4.1.1 Texture measurements of the preliminary recipe

Recipes 1 and 2 had the highest percentage (97.3%) of fish and protein content (19.4%). Our primary objective was to measure the products' hardness, using texture analysis, with the two texture modifiers, Farinex and Agar. The secondary objective was to investigate the effect of the two texture modifiers on taste, cohesiveness and colour.

Table 3. Recipes 1 and 2 with the percentage of the ingredients and the two texture modifiers, Farinex and Agar.

	Recipe 1	**Recipe 2**
Ingredient	**%**	**%**
Salmon	97.3	97.3
Salt	0.8	0.8
Oil	1.0	1.0
Farinex	1.0	-
Agar	-	1.0
Total protein content %	19.4	

In age-care facilities, texture-modified products may be stored frozen or kept in a fridge for a period of time after production. Therefore, testing the texture after a storage period was necessary to research the change in texture after a period of time. Figure 14 shows the mean value and standard deviation (±SD) in the textural analysis measured for Farinex and Agar processed with heat treatment (HT) and two different high pressure (HPP) treatments at week 0 and week 3, compared with the control sample.

Figure 14 shows small differences between the control sample and the Agar and Farinex products. Even with the different treatments, the hardness of all the products did not alter significantly, as seen in Figure 14. Measured texture in Hardness (N) for the control sample (Sandnes MS) and the different recipes Farinex (F) and Agar (A) with different treatments: High-Pressure Processing (HPP) at 400 and 600 MPa, and Heat Treatment (HT). The results are shown for week 0 (F0, A0) and week 3 (F3, A3). Letters were placed on the diagram to conduct the statistical analysis of the differences in texture. The only significant difference was observed for the Agar products that received HT and HPP at 600 MPa at week 3.

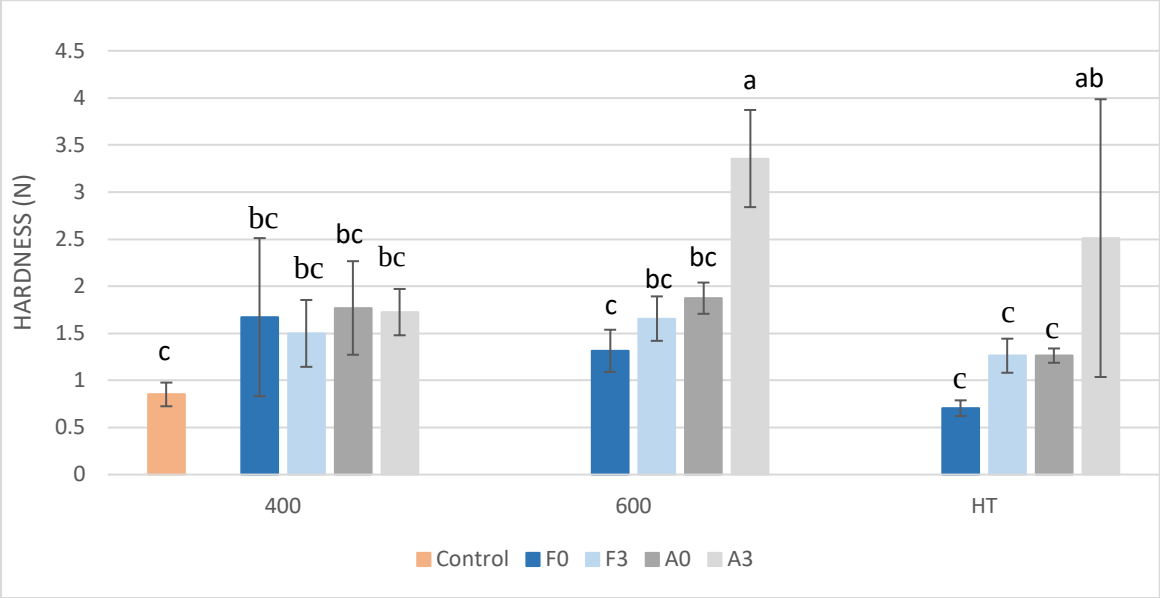

Figure 14. Measured texture in Hardness (N) for the control sample (Sandnes MS) and the different recipes Farinex (F) and Agar (A) with different treatments: High-Pressure Processing (HPP) at 400 and 600 MPa, and Heat Treatment (HT). The results are shown for week 0 (F0, A0) and week 3 (F3, A3). Letters were placed on the diagram to conduct the statistical analysis of the differences in texture.

The results obtained from the texture measurement can be explored further to understand what caused the differences. The control sample showed much lower hardness (N) than Agar at HPP (600 MPa) and HT. This could be due to there being less fish in the recipe. Recipes 1 and 2 with Agar and Farinex contained 97% fish, while the control recipe contained 73.3%. By observing the lower hardness value, it was possible to deduce that the total amount of liquids in the recipe played a significant role in the hardness of the products.

In Table 1, categories of values for hardness at 0.7-4.4 N pureed meat products are presented. By looking at Figure 14, all the products had a hardness below 4.4 N, and the Farinex sample with HT was 0.705 N at week 0. This indicates that the product was at a level that is categorised as pureed food. The other results indicate that the control sample and recipes 1 and 2 gave a suitable dysphagia product regardless of the treatment.

A slight increase in hardness for Farinex was observed at 600 MPa and HT from week 0 to week 3. According to Nishinari et al., (Nishinari et al., 2016) , starches are prone to

thixotropic behaviour (time-dependent behaviour), which reduces the structural strength of the product. The reduction in total strength can make the starchy product less stable and could explain why a slight increase in hardness was seen for 600 MPa and HT.

In this study, the Agar recipe had a significantly higher hardness at week 3 for HPP (600 MPa) and HT. In a study by Chen (Chen et al., 2014), polysaccharides with gelling abilities were tested during different pressures of High-Pressure Processing. The study found that HPP at 100-400 MPa could significantly decrease the gel strength of myosin in meat products. In the study conducted by Chen et al., (Chen et al., 2014) the gel strength at 400 MPa led to decreased gel strength. In our research, we likewise observed that the treatment at 400 MPa decreased the gel strength enough to lead to a product as soft as the control sample.

4.1.2 Colour measurement of preliminary recipe

Colour is often measured and analysed to describe the characteristics of a product. Factors such as colour and appearance are essential as they can be crucial for the patient's appetite and choice of product.

Colour measurements were done by taking a photograph using CIELAB, as described in 3.2.3 Colour measurement of the preliminary product. L* measures the pigmentation from 0-100 (0 – black, 100 – white), and a* shows the red/green colour axis of the product by measuring it in values shown either as positive or negative. The same negative/positive values go for b*, indicating a yellow/blue colour (17)

Compared to the control sample, similar values were observed for all the products that received HPP at 400 MPa, only differing for Farinex at week 0 (Figure 15). For HPP at 600 MPa, similar values were observed for all products, where only Agar at week 0 showed significant differences from the control sample. Compared to the control sample, the HT Farinex product was darker at weeks 0 and 3. Similarly, darker colours were seen at week 0 for Agar with HPP (600 MPa) and Farinex with HPP (400 MPa).

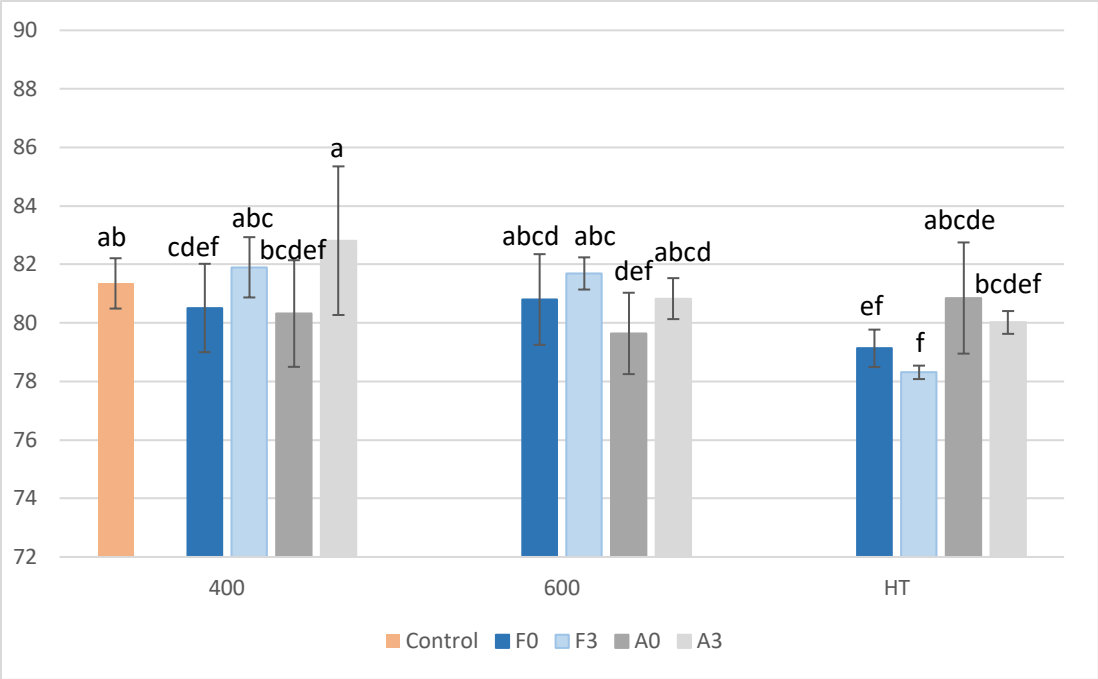

Figure 15. The measured lightness (L*) values (mean ±SD) for the control sample and recipes 1 and 2 (containing Agar and Farinex) and their treatments; High-Pressure Processing (HPP) at 400 MPa and 600 MPa, and Heat Treatment (HT). The results are shown for Farinex (F) and Agar (A) at week 0 (F0), (A0) and week 3 (F3), (A3).

Figure 16 shows red and green colours in negative or positive values. When the value is positive, the product is red. The only significant differences were observed at week 0 for Agar with HT. The statistical analysis also showed that HPP at 400/600 MPa and HT do not significantly change the redness of the product.

Consumers often associate the degree of redness with product quality. A study was conducted by Lehnert et al., where they found that the redness levels of a salmon filet could vary in different aquatic environments (Lehnert et al., 2019). Thus, the tiny colour differences could be due to the salmon in the control recipe having a different origin than the salmon received to obtain the recipes for this study. However, the difference was too small to allow us to conclude that the product's origin was the reason.

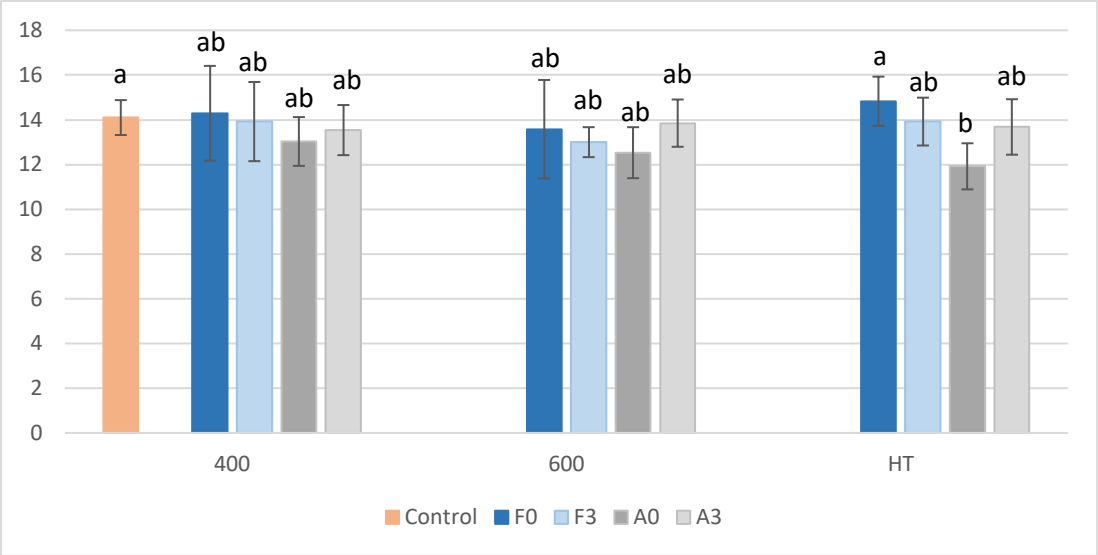

Figure 16. The measured red-green (a*) values (mean ±SD) for the control sample and recipes 1 and 2 (containing Agar and Farinex) and their treatments; High-Pressure Processing (HPP) at 400 MPa and 600 MPa, and Heat Treatment (HT). The results were shown for Farinex (F) and Agar (A) at week 0 (F0), (A0) and week 3 (F3), (A3).

When measuring yellow/blue colour, positive values indicate yellow colours, and negative values indicate blue colours. The results in Figure 17 show only positive values for the preliminary recipes and treatments, indicating no blue tones in the product. In Figure 17, we see that the yellowness of the products was similar for most of the products.. From the results observed in Figure 17, it was clear the different treatments did not significantly influence the yellowness of the product. The statistical analysis showed that all the products shared at least one letter, which indiciated that they were significantly similar.

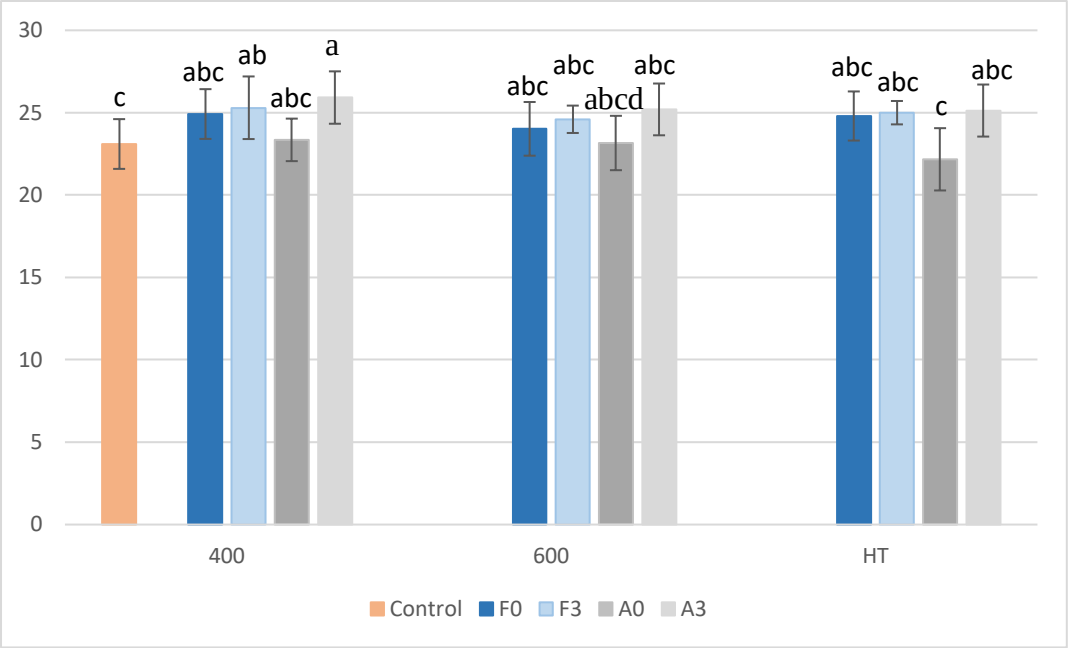

Figure 17. The measured yellow-blue (b*) values (mean ±SD) for the control sample and recipes 1 and 2 (containing Agar and Farinex) and their treatments; High-Pressure Processing (HPP) at 400 and 600 MPa, and Heat Treatment (HT). Farinex (F) and Agar (A) at week 0 (F0), (A0) and week 3 (F3), (A3).

4.1.3 Microbiology on the preliminary recipe

After producing the preliminary recipe, microbiological analysis was performed to register the number of microorganisms found in the product immediately after the production date and again after three weeks. Microbiological tests are essential for the storage of information and the safety of the product. The samples were refrigerated at 4 °C between the two microbial measurements. Two control samples were used in week 0. These two samples differ from the control sample (Sandnes Matservice) throughout the thesis. The control samples in this microbiological analysis were mixed variants of the Farinex and Agar products. The samples received the same plastic casings but no further treatment (HT or HPP). These control samples were called Mixed Farinex (MF) and Mixed Agar (MA).

In Figure 18, a detection line was put on 2.3. Figure 18 shows that the number of colonies found in the sample was low. The enumeration method, using Eddy Jet to spread the sample on the microbial agar plates, led to a high detection level of 2.3 cfu/g. The control product did not receive HT or HPP and showed the microorganisms present in the raw materials and ingredients on day 1. These results indicate that these treatments were sufficient to ensure

minimal growth of microorganisms in the product. HT showed the lowest number of microorganisms on day 1 for both the Agar and Farinex product (estimated to be below the detection level). On day 21, the number of microorganisms slightly increased. However, the increase observed still showed a low number of microorganisms, with mean values below log 3 cfu/g. These results indicate that the product is safe to consume at day 21 when HT and HPP (at 400 and 600 MPa) were used. There was little difference in HPP and HT microbial counts, which means that it is possible to replace HT with HPP and thus get equally safe products but with better quality. For future works, it can be useful to take more microbial analysis, increase the storage time and include analysis for spore-forming bacteria like *Bacillus* (2.3 Food safety**.**

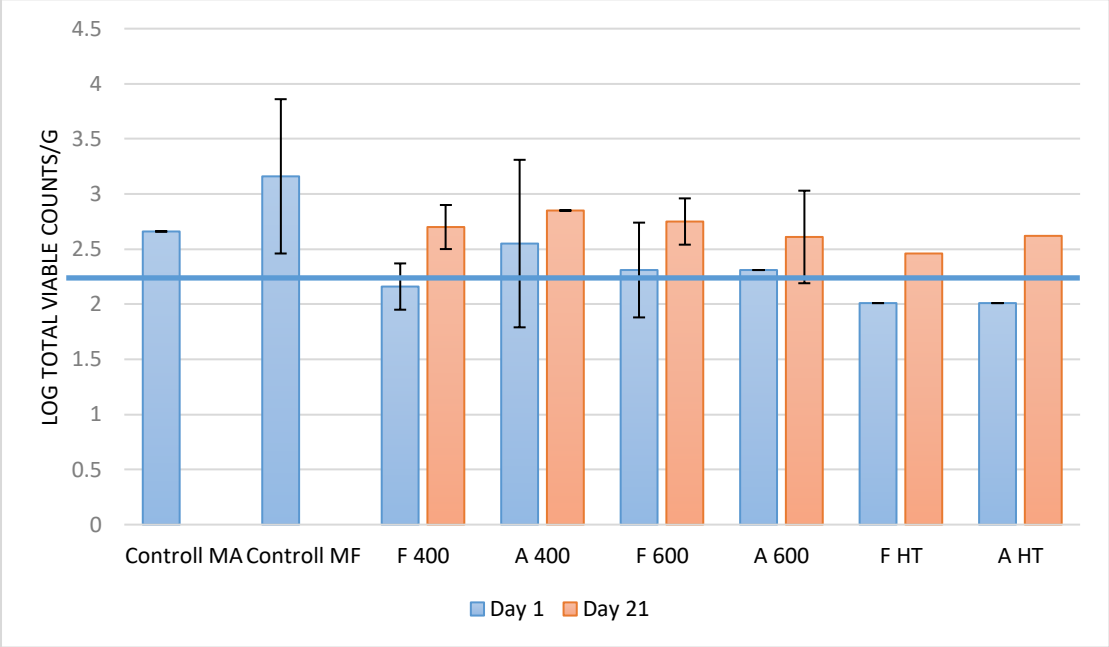

Figure 18. Microorganisms found in the product on day 1 and again on day 21 for Farinex (F) and Agar (A) at the different treatments (High-Pressure Processing at 400 and 600 MPa) and Heat Treatment (HT). Included are control tests of Agar (Control MA) and Farinex (Control MF), where no treatment was received. The vertical line represents the detection level for the method (Log 2.3 cfu/g).

4.2 Measurements on the adjusted recipes and the control sample

After the first textural analysis, new recipes (3-6) were developed, all containing Farinex. The adjusted recipes are shown in Table 6. Measurements of texture and colour were done as in the preliminary products for these. Recipes 7-9 were created, containing Agar and eliminating 2% oil from the recipe (Table 7). These recipes contained a reduced protein content of 14.9% as opposed to 19.4% in the preliminary recipes ().

Table 6. Recipes 3-6 with Farinex and the percentage of the different ingredients

	Recipe 3	**Recipe 4**	**Recipe 5**	**Recipe 6**
Ingredient	**%**	**%**	**%**	**%**
Salmon	75.0	75.0	75.0	75.0
Salt	0.8	0.8	0.8	0.8
Oil	0.0	1.0	2.0	3.0
Farinex	1.0	1.0	1.0	1.0
Water	23.2	22.2	21.2	20.2
Total protein content %	14.9			

Table 4.3 Recipes 7, 8, and 9 with Agar and the percentage of the different ingredients.

	Recipe 7	**Recipe 8**	**Recipe 9**
Ingredient	**%**	**%**	**%**
Salmon	75.0	75.0	75.0
Salt	0.8	0.8	0.8
Oil	0.0	2.0	3.0
Agar	1.0	1.0	1.0
Water	23.2	21.2	20.2
Total protein content %	14.9		

4.2.1 Texture measurement on the adjusted recipes

Figure 19 shows the results of the adjusted recipes containing 75% fish and various prespecified amounts of oil. Statistical analysis showed that the measured hardness differed from the control sample. After adjusting the recipe, it was clear that the control sample was the hardest. The figure shows that recipes that had received frozen treatment were harder than the same receipe after heat treatment (HT).

For the Agar products, significant differences were seen compared to the control sample. The recipes made by Sandnes Matservice (control sample) did not have oil but had fish broth instead. The question then was whether the amount of oil in recipes 7-9 influenced the hardness levels of the product. However, recipe 7 (without oil) was still very different from the control sample (without oil), indicating that the difference did not come solely from the added oil. For the Agar products, the only significant differences between the two treatments were observed for the 1% oil variant.

Figure 19 also shows that the products containing Farinex with FT are more similar to the control sample. Figure 19 also shows that the hardness was significantly higher for the Farinex products that received FT than those that received HT. A study performed by Haq et al., (Haq et al., 2020), could explain these differences. They found similar results when studying the effect of freezing on starches as starches at low temperatures (after gelatinisation) form the recrystallisation of starch granules. This increases the resistance and hardness of starch. These differences could show that the structures of Farinex were more sensitive to temperatures while the structures of Agar were more stable.

There could be several reasons why the hardness of the products was so different from the control sample. The hardness levels were different despite the similar percentage of fish, which indicated that the change did not only come from the change in the fish content. It was observed that the Farinex products that received frozen treatment were significantly harder than those of Farinex that received heat treatment.

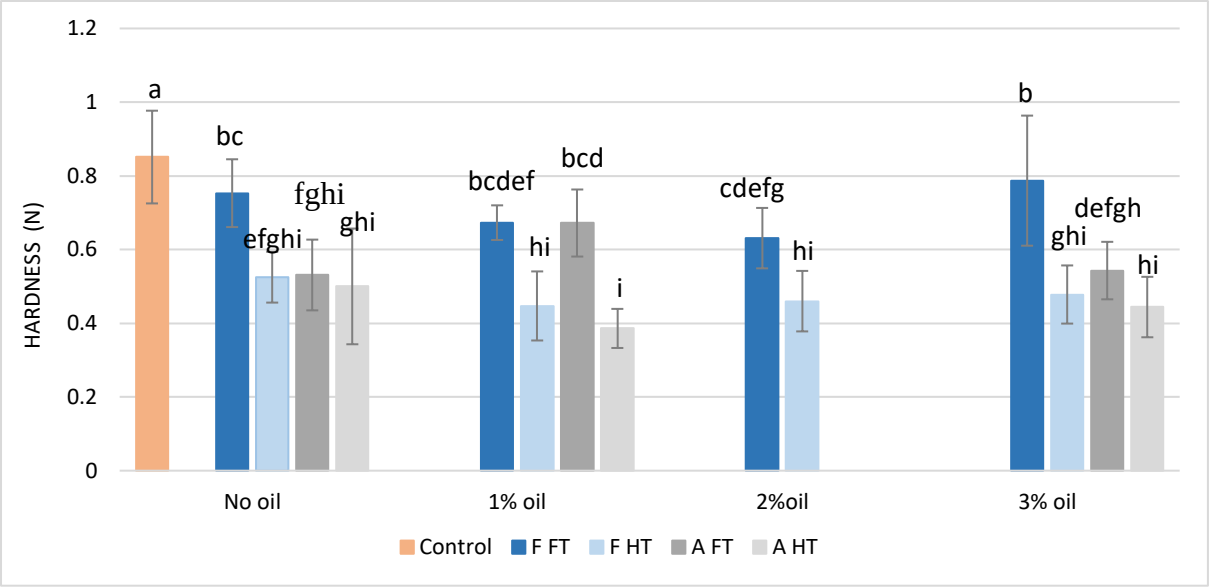

Figure 19. Measured texture in Hardness (N) (mean ±SD) for the control sample and the different Farinex (F) and Agar (F) recipes with Heat Treatment (HT) and Frozen Treatment (FT).

4.2.2 Colour measurement on the adjusted recipes

A colour measurement was performed with the texture measurements of the adjusted recipes to observe the colour differences when the fish percentage was decreased. The same statistical analysis was performed, and similar values (no significant differences) in colour between the samples were observed.

In Figure 20 the Agar products without oil show similarities to the control sample with HT and FT. The Agar products with 3% oil were also similar to the control sample with FT. A significant difference was observed for the 3% oil product containing Agar, where FT and HT differed significantly. The results in Figure 20 also showed that the treatments did not greatly influence the product's lightness. The figure also showed that the amounts of oil added to the product did not greatly change the product's lightness. Even with 3% oil, the frozen Agar products were similar to the control sample (without added oil).

The Farinex products were seen to have significantly different lightness compared to the control sample, while the Agar products had significantly similar lightness as the control sample (also containing Agar). From these observations, it seems that the two texture modifiers are the only factors influencing the product's lightness.

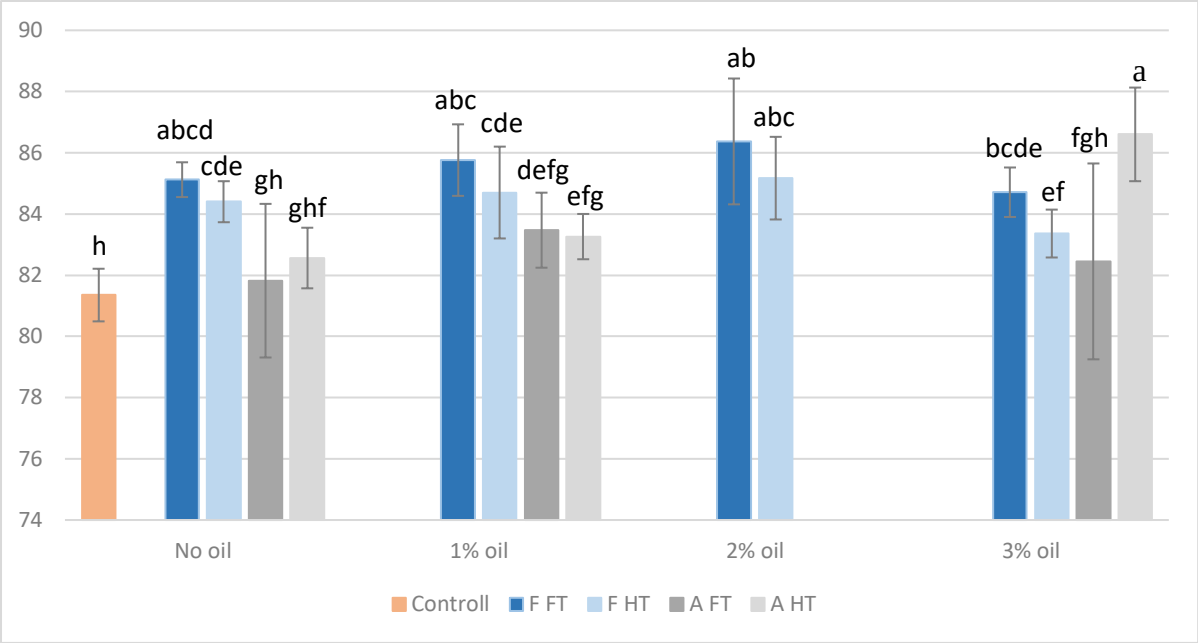

Figure 20. Measured lightness (L*) values (mean ±SD) for the control sample and the adjusted recipes 3-8 containing Farinex (F) and Agar (A) with different quantities of oil after heat treatment (HT) and frozen treatment (FT).

The control sample, as seen in Figure 21 had a much higher redness than all of the products produced with and without oil. Although the products had a similar percentage of fish (73.3% vs 75%), the colour difference could have been caused by the different liquids in the control sample and the Farinex and Agar products. The control sample contained fish broth instead of oil and water, which could significantly affect the product's colour. Differences in yellowness were also observed for the Agar and Farinex that received HT and FT. The FT products were seen to have a darker redness when the products had been frozen. These results could all indicate that the redness was influenced mostly by the treatment received. As was seen in Figure 20, all the products were lighter than the control product. This might be due to the higher redness in the control sample.

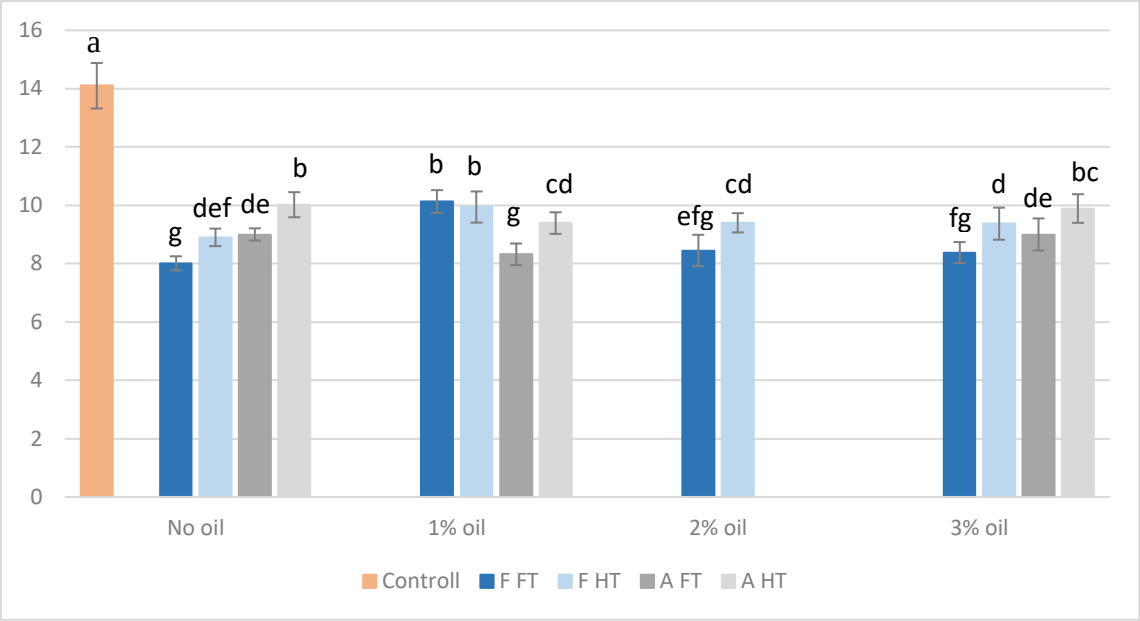

Figure 21. Measured red-green (a*) values (mean ±SD) for the control sample and the adjusted recipes 3-8 containing Farinex (F) and Agar (A) with different quantities of oil after heat treatment (HT) and frozen treatment (FT)

Figure 22 shows yellow values obtained from the research. The highest significant difference was observed for the Agar products that received FT, which contained no oil and 3% oil. Many similarities were observed between the products. For Farinex, the yellowness significantly differed between the HT and FT products. The same was observed for the Agar products that contained 3% oil. Once again, it seems that the treatment that the product received is what influenced the yellowness the most.

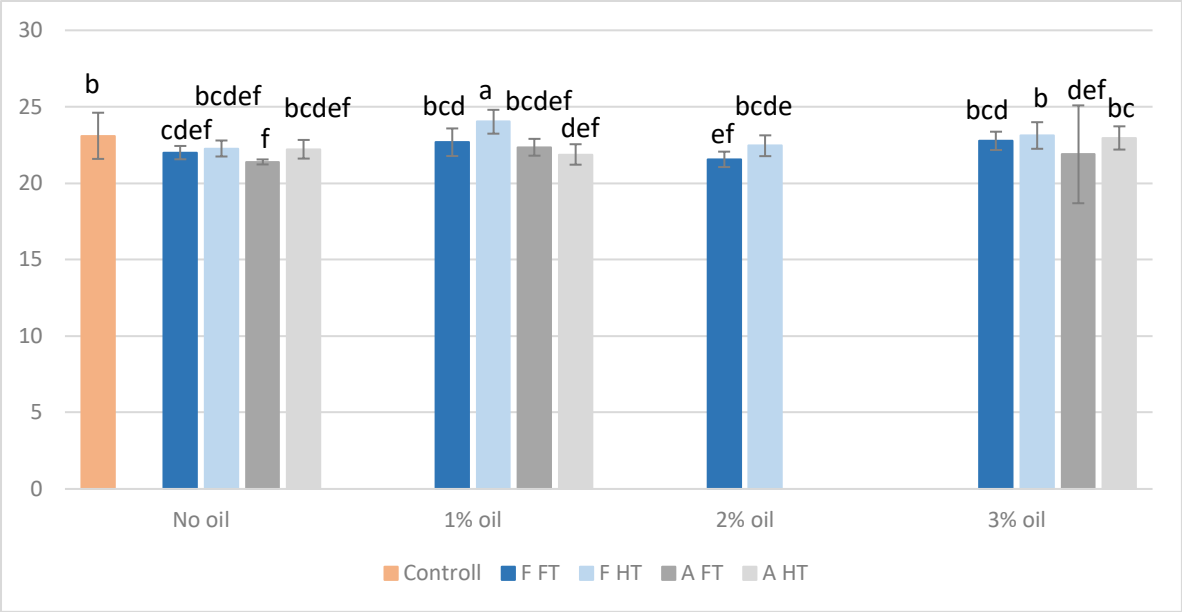

Figure 22. Measured yellow-blue (b*) values (mean ±SD) of the control sample and the adjusted recipes 3-9 containing Farinex (F) and Agar (A) with different quantities of oil after HT and FT.

4.2.3 Rheological measurement on the adjusted recipes

Performing rheology is essential as it can give insight into the product's viscosity and how it acts when applied with a particular force. Rheology was conducted to understand better how the product would feel in the mouth while giving more precise information on the chewiness and risk of aspiration.

Storage modulus at the end of LVR (G' LVR) showed that the Farinex product with 3% oil was not altered significantly compared with the control sample when frozen treatment (FT) was received (Figure 23). The Farinex products with no and 1% oil had the highest storage modulus after FT compared with all the other products. A significant difference was also observed between the different treatments (HT and FT) for the Agar products. We observed an increase in G' after FT in all products. Farinex had the highest increase, and Agar had a lower increase, but was still significant. A reason for this could be the different stability of the products. Agar seems to be more stable and does not change much when receiving different treatments. Giura et al, 2022 (Giura et al., 2022) conducted a study where they found that Xanthan gum is a hydrocolloid with great stability over time and good temperature resistance. Xanthan gum is often categorised along with Agar as they are both hydrogels (Gao et al.,

2017). Therefore, Agar has similar characteristics as Xanthan gum, which might explain why the Agar products had a small change in storage modulus (G') between FT and HT.

In a study by Wright et al., (Wright & Marangoni, 2006) studied the gel structure and stability of vegetable oil-based organogels. They found that the linear viscoelastic region storage modulus (G' LVR) changes when different concentrations of canola oil are used. They found that 0.5% canola oil gel behaved like a weak, viscoelastic network. At levels between 1 and 5% canola oil, solid-like viscoelastic gels were formed. Thus, the G'LVR was highly dependent on the concentration of oil. From our results, the highest G'LVR was observed at Farinex at 0 and 1% of oil. This indicates a stiffer sample, thus, better flexibility and elasticity (Giura et al., 2022). In our study, the results were the same when the oil concentration was 1%. However, when the percentage of oil was 3%, the G'LVR decreased, which makes it hard to conclude if our results support the results of Wright et al..

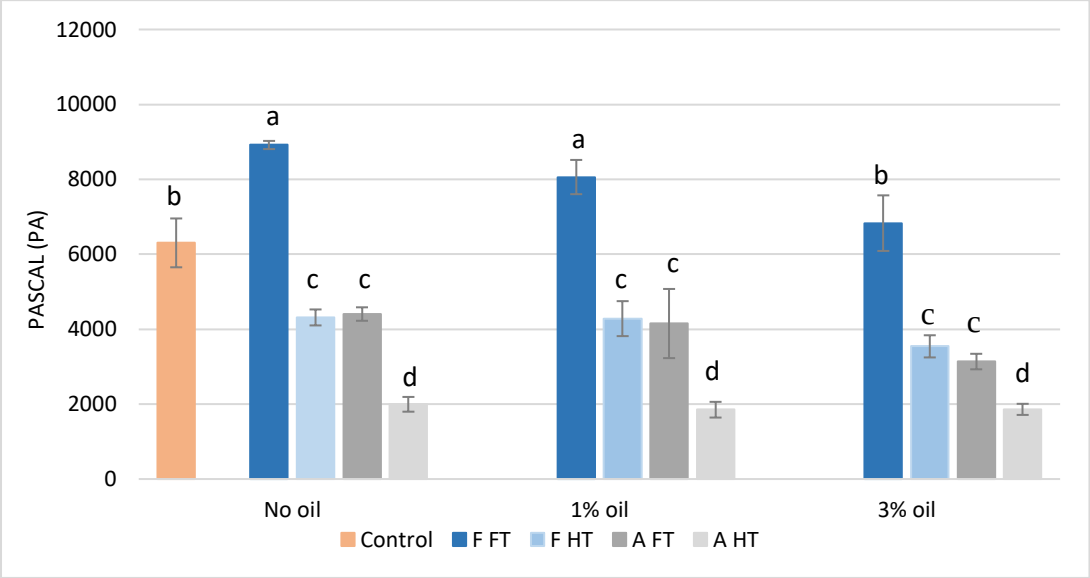

Figure 23. Storage modulus LVR (G' LVR) was measured at 1 Hz and 0,01-200% strain for the control sample and the different recipes containing Agar (A) and Farinex (F) for heat treatment (HT) and frozen treatment (FT).

When looking at the yield stress (Figure 24), we see that the FT and HT Farinex products had yield stress that differed significantly from the control sample. The control sample had the same yield stress as all HT Agar products (no significant difference). Of all the products, the Farinex products had the highest yield stress. Zarim et al., (Abu Zarim et al., 2018) mention

that higher yield stress is important as it characterises higher particle interactions and better resistance to flow. This is important to form a cohesive bolus that can reduce aspiration in dysphagia patients (Abu Zarim et al., 2018). Higher yield stress indicates that the Farinex samples are generally more elastic and flexible than the Agar products and the control sample (Giura et al., 2022).

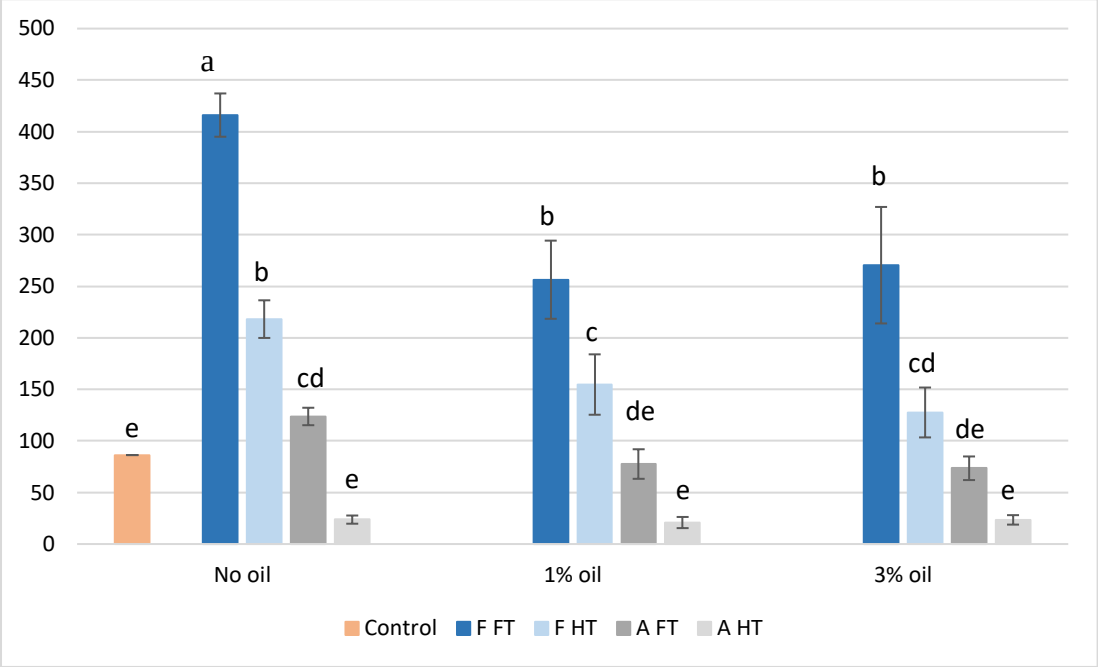

Figure 24. Yield stress measured at 1 Hz and 0.01-200% strain for the control sample and the different recipes containing Agar (A) and Farinex (F) for HT and FT.

Figure 25 shows that the highest Flow Point was observed for the Farinex products that received frozen treatment (FT). The lowest values were observed for the Agar products that received heat treatment (HT). The figure shows that the flow point was generally lower for the HT compared to the FT samples. No significant differences in flow point were observed between the different amounts of oil added to the products.

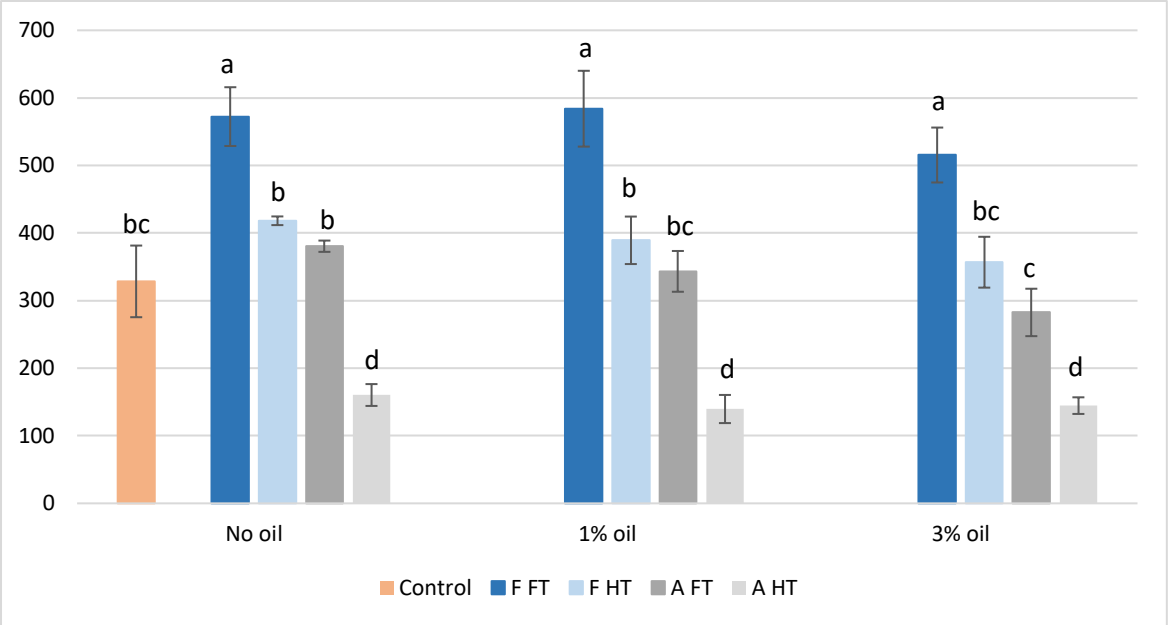

Figure 25. Flow point measured at the 0.01-200% shear rate for the control sample and the different recipes containing Agar (A) and Farinex (F) for heat treatment (HT) and frozen treatment (FT)

Viscoelastic parameters are obtained from Frequency sweep at 1 Hz frequency and are presented in Table 8. Storage (G') and Loss (G'') modulus found for the control sample and the Farinex and Agar products with different amounts of oil and treatments (heat and frozen treatments) found from the performed Frequency Sweep. Results show that the storage modulus (G') was higher than the loss modulus (G'') in all samples over a range of frequencies, indicating a weak gel structure. The tan delta supports this result (δ) value shown in Figure 26, which shows higher values for the Agar products for both treatments. Agar's highest value was 0,121 (1% oil, HT). The values for the Farinex products showed minimal differences between the different oil amounts. Farinex without oil and with 1% oil showed similar results, only varying with 0,01. Agar's results were the same without oil and with 1% oil for the products that received FT.

Figure 26 shows the product to be of desired texture. Tan delta (δ) values below 0,6 indicate a weak gel structure, adequate for dysphagia patients (3.3.3 Rheology measurement on the adjusted recipe. Viscoelastic properties were also presented with a viscoelastic power law. The results showed b>0.09, indicating that the value increase was low as frequency increased. An increasing G' and G'' with increasing frequency indicates a weak gel.

In Table 2, different Hardness (N) and Storage Modulus (G') are presented for the different "products". Table 8 shows that the storage modulus (G') was between 1600 Pa (for jellied food) and 11000 (for pates). The control sample had a storage modulus of 6369.78 Pa but a hardness of 0.851 N. This shows values that range within the different textures which indicates a product hard enough (N) to be timbale/pureed food but not stable enough to be categorised as a timbale/pureed food. Since all the products had hardness levels between 0.4-0.850 N, categorising the different products was challenging. A better categorisation can be made by observing multiple rheology results.

Table 8. Storage (G') and Loss (G'') modulus found for the control sample and the Farinex and Agar products with different amounts of oil and treatments (heat and frozen treatments) found from the performed Frequency Sweep.

Sample	Treatment	G' Pa	G'' Pa
Control	FT	6369,78 (949,32)^{b}	1586,36 (274,08)^{a}
F no oil	FT	8558,91 (534,58)^{a}	1511,5 (73,87)^{a}
	HT	3966,92 (185,25)^{c}	674,40 (22,99)^{bc}
F 1% oil	FT	7864,64 (461,06)^{a}	1386,32 (88,34)^{a}
	HT	4040,59 (285,85)^{c}	684,42 (56,73)^{bc}
F 3% oil	FT	6604,69 (810,23)^{b}	1164,2 (149,34)^{a}
	HT	3564,94 (263,77)^{c}	590,56 (43,90)^{bc}
A no oil	FT	3994,42 (155,66)^{c}	810,6 (29,50)^{b}
	HT	1814,75 (167,77)^{d}	358,61 (37,14)^{c}
A 1% oil	FT	3170,75 (554,54)^{c}	640,73 (101,56)^{bc}
	HT	1702,47 (154,94)^{d}	360,7 (28,50)^{c}
A 3% oil	FT	3070,51 (81,34)^{c}	634,41 (22,12)^{bc}
	HT	1758,17 (134,27)^{d}	357,49 (27,68)^{c}

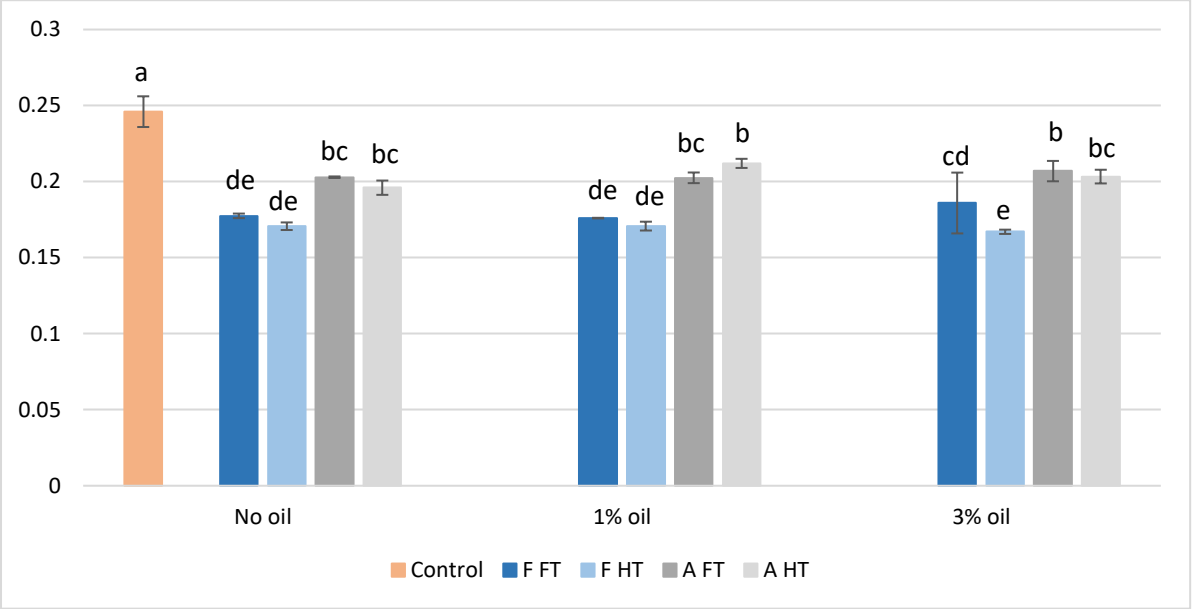

Figure 26. Loss tangent (tan δ, G″/G′) (mean ±SD) measured at 0,1-10 Hz for the control sample and the different recipes containing Agar (A) and Farinex (F) for heat treatment (HT) and frozen treatment (FT).

A flow sweep was performed to get an indication of the viscosity of the product. The viscosity at different shear rates is presented in Figure 27 at a shear rate of 1 1/s and in Figure 28 at a shear rate of 10 1/s.

In previous work done by Ross et al., (Ross et al., 2019), a strong correlation between viscosities at a shear rate of 10 1/s and oral cohesiveness was seen, showing that samples with higher viscosities at a given shear rate form more cohesive boluses. This can mean that Farinex samples that have the highest viscosity at a shear rate of 10 1/s should be most suitable for the formation and maintenance of a bolus. The same correlations could be seen for shear rates at 1 1/s, where Farinex without oil showed the highest value for FT. HT Farinex samples had significantly lower viscosity from FT Farinex. Thus, the structures of the Farinex were ruined in the HT. There were significant differences between Farinex without oil compared to samples that had oil. However, no significant differences were observed between 1 and 3% oil. Interestingly, there were no significant differences between FT and HT for Agar. Even if Farinex was seen to have a higher viscosity, the huge differences between FT and HT could mean that the product is unstable and, therefore, unreliable. It is hard to predict how the product will react at different temperatures. Agar had no significant changes

between the two treatments, which indicated that Agar could be a better option as one is sure that the product will perform as desired.

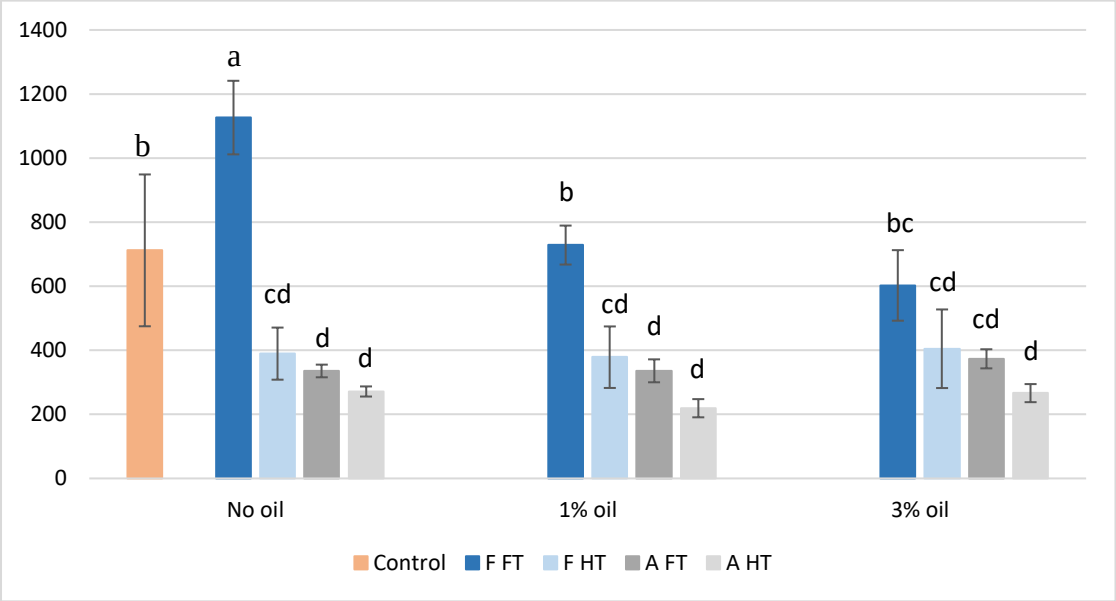

Figure 27. Viscosity measured at 1/1S (mean ±SD) for the control sample and the different recipes containing Agar (A) and Farinex (F) for heat treatment (HT) and frozen treatment (FT).

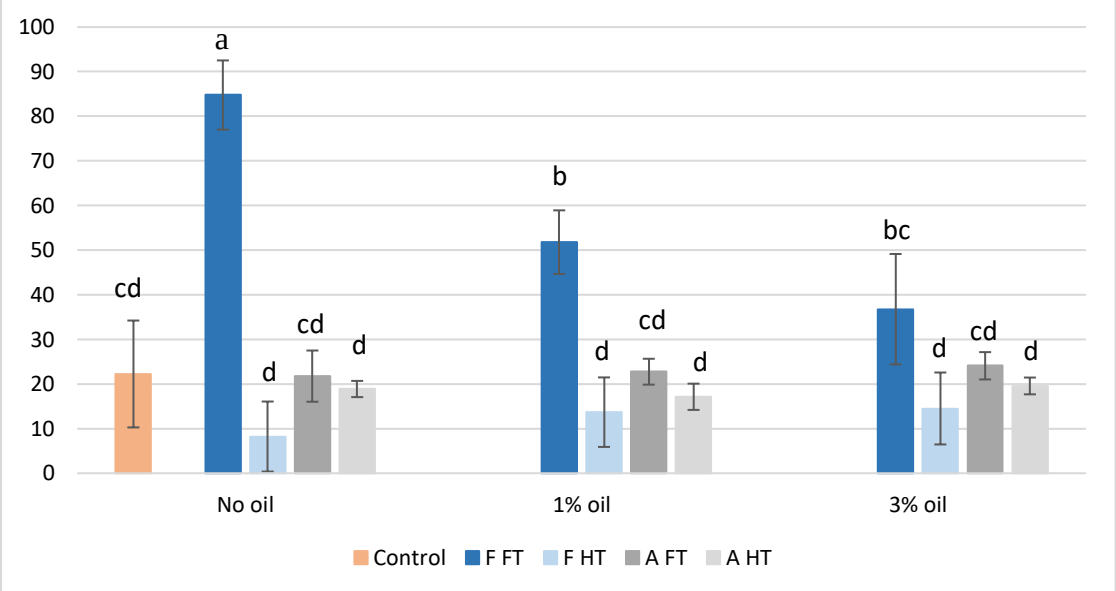

Figure 28. Viscosity measured at 10/1S (mean ±SD) for the control sample and the different recipes containing Agar (A) and Farinex (F) for heat treatment (HT) and frozen treatment (FT).

The results on viscosity at 1 1/s and 10 1/s showed Farinex to have the highest values after FT but the lowest at HT at 10 l/s. Considering that the Farinex product without oil was the hardest at FT in all viscosities (1 1/s and 10 1/s), one could conclude that Farinex had the best resistance to flow and a lower shear rate. Since higher-viscosity foods give individuals more time to prepare the food bolus, Farinex without oil could be considered the safest recipe to include in dysphagia management as higher-viscosity foods are more accessible to swallow than liquid. In our study, the flow behaviour showed decreasing effect for the frozen treated (FT) products at 1/s. The decrease in viscosity levels after FT could be challenging as aged care facilities often freeze their products during storage.

4.3 IDDSI measurement on the adjusted products

A Spoon Tilt test was performed on the control sample and samples from adjusted recipes to examine the cohesiveness. The objective was to see if the product fell off when the spoon was tilted or if it was sticky enough to stay on the spoon (2.4 **IDDSI - The International Dysphagia Diet Standardization Initiative**.

The results from the Spoon Tilt Test were significantly different when variables were compared as the texture of different modifiers, amounts of oil and treatments. At least three test parallel samples were carried out per recipe to find an overall effect for each variant. All the samples were pre-heated and cut to be as even as possible. A mouthful was taken and tested from each sample.

For the control sample (Sandnes Matservice), the Spoon Tilt Test gave apparent indications of the cohesiveness of the product. In total, 12 parallels were done, and only one parallel stayed on the spoon while the rest fell off. This indicated that although the product had no oil, the results showed a more cohesive product, which will feel less sticky in the mouth of the consumer.

The multiple Spoon Tilt Tests performed on the adjusted recipes showed various results. Even within the same variant, the results showed that the product fell off the spoon once and stayed on the spoon the next test. This indicates that this test is quite rough and partly subjective and requires some training and experience to give reproducible results. Fewer samples fell off the spoon for the variants containing oil with heat treatment (HT) for both Farinex and Agar, with

little or no food left on the spoon. Figure 29 shows an example of how this test was performed.

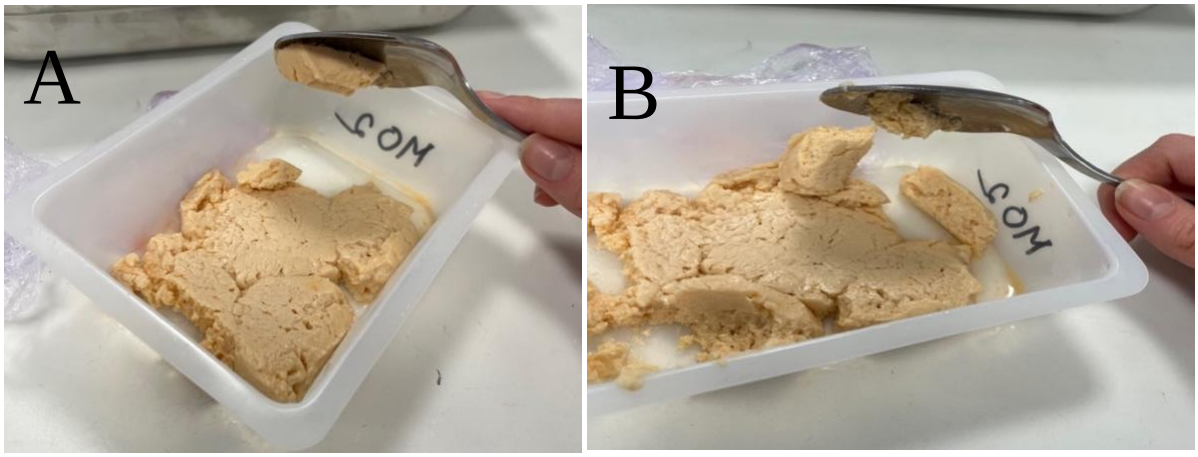

Figure 29. Spoon Tilt Test is done on Farinex product with 1% oil for a product with heat treatment, showing the product covering half of the spoon in A. Picture B shows that most of the product fell off the spoon, with only a tiny amount clinging to the spoon. The temperature measured before the test was 32.7°C.

The results from the Spoon Tilt Test containing Farinex (Table 9) show that the product fell off the spoon about 60% of the time for the product containing 0 and 1% oil with frozen treatment (FT). For the heat treatment (HT), 37.5% of the product without oil and 33.3% of the product containing 1% oil fell off the spoon. A different result was observed for 3% oil, where the product fell off the spoon 61.5% of the time after HT and 0% of the time after FT. The last results indicate that this variant should be tested again in further experiments.

Table 9. Spoon Tilt Test of the products containing Farinex, indicating how often (in percent) the product fell off the spoon.

	No oil		**1% oil**		**3% oil**	
Treatment	FT	HT	FT	HT	FT	HT
Fell off spoon	61.5%	37.5%	60.0%	33.3%	0.0%	61.5%

In Table 10, the largest percentage of “falls of the spoon” was observed in the Agar products that received frozen treatment (FT). The rate was highest for the Agar product with no oil (72.7%), followed by the product with 1% oil (66.6%), and least for the frozen treatment product with 3% oil (33%).

Table 10. Spoon Tilt Test of the products containing Agar indicates how often (in percent) the product fell off the spoon.

	No oil		**1% oil**		**3% oil**	
Treatment	FT	HT	FT	HT	FT	HT
Fell off spoon	72.7%	41.6%	66.6%	16.6%	33.0%	7.7%

5 Conclusions

In total, 9 recipes were developed to determine suitability for dysphagia patients. The tests were compared with a control sample received from a community municipal kitchen. Sandnes Matservice primarily wanted to learn how to expand the range of texture-adapted food for dysphagia patients. The recipes were developed with a series of treatments to further research which treatment gave the best dysphagia product.

The texture-modified product contained salmon, and the two texture-modifiers, Farinex and Agar, with different amounts of oil and water. The results obtained in this thesis showed that the product became softer when the overall fish content in the recipe was reduced and replaced with liquids (oil and water). Adding oil to the products gave a less “grainy” product. A vast colour difference was observed between the control sample and the products produced in this thesis, even with similar fish contents.

Texture and rheology measurements gave information about how the products react in the mouth and the safety of the products regarding dysphagia. The hardness (N) and storage modulus (G’) values categorised foods as paté or timbale/pureed. These values showed that the control sample (Sandnes Matservice) was within a pate-texture food and a timbale (level 4

IDDSI). The IDDSI Spoon Tilt Test also concluded this. When performing this test, the sample fell off the spoon 95% of the time, which is required for IDDSI Level 4.

Dick et al. stated that foods with hardness levels of 0.7-4.4 N could be categorised as pureed (IDDSI Level 4) foods. The preliminary recipes created in this thesis showed all hardness (N) values to be within this range. However, rheology measurements and the IDDSI Spoon Tilt Test was not performed for the preliminary recipes, which makes it harder to conclude the level of these samples.

From the preliminary recipes, new recipes were created with Farinex and Agar, which contain different amounts of oil. These recipes received heat and frozen treatments. The Farinex products had low hardness (N) values, higher yield stress, higher storage modulus, a higher viscosity (at 1/10 1/s) and a tan delta level of 0.6. From these results, one can indicate that the Farinex product was the safest for swallowing. However, all these results alone can not conclude that the Farinex product was the most adequate for Dysphagia patients. The Farinex products showed significant differences between heat treatment (HT) and frozen treatment, making them less reliable.
The Agar products showed a low yield stress and lower viscosity levels, which could mean that the product is more liquid, indicating a less adequate Dysphagia product (compared to Farinex). However, for the Agar products, significant differences were observed between the treatment. These differences were not as big as for Farinex (between the two treatments). The little changes may imply that the product is more stable in different temperatures than Farinex.

The results from the Spoon Tilt Test were significantly different when variables were compared as the texture of different modifiers, amounts of oil and processing treatments. These variations for the Spoon Tilt Test performed on adjusted recipes showed that this test is quite rough and partly subjective and requires more training and experience to give reproducible results. A higher number of frozen products fell off the spoon compared to the heat treated. A trend was that lower numbers fell off the spoon with increased added oil (except 3% Farinex). For the control sample (Sandnes Matservice), the Spoon Tilt Test showed that although the product had no oil, the results showed a more cohesive product, which will feel less sticky in the mouth of the consumer.
with increasing

The colour measurements showed that the control sample was darker and had higher redness and yellowness values. These three colour characteristics could indicate a more colourful product, making it more appealing to consumers.

The microbiological analysis showed more colonies for the control samples (MF and MA) without treatment. In the preliminary production, the lowest number of colonies was observed for the heat-treated (HT) products on day 1. The samples of both HT and HPP had a lower number of microorganisms until day 21, where the mean values were below log 3 cfu/g). These results indicated that the product is safe to consume at day 21 when HT and HPP (400 and 600 MPa) are used. There was little difference in HPP and HT microbial counts, which means it is possible to replace HT with HPP and thus get equally safe products but receive better-quality products.

Future work

- Since protein content is crucial to reduce malnutrition and sarcopenia, similar experiments and products can be made with recipes containing extra protein.
- The same experiment could also be done using other types of fish to study if the type of fish greatly influences the texture and nutritional value. Different fish types have different nutrients, which can provide a more balanced diet.
- There is a lack of packaged and chilled texture-modified products available in supermarkets. Further experiments with various processing conditions (HPP, HT and others) and shelf-life studies, including sensory analysis, should be conducted.
- A Frequency Sweep could be performed with different eating and serving temperatures to better document how the different temperatures affect texture, cohesiveness, colour and other important factors. In this thesis, the measurements were performed at 60^{o}C. Examination of how the products reacted at different temperatures, such as 10, 25 and 40 etc., will add important information to understand the temperature's influence on the of texture. Checking how the products reacted at
- Similar experiments could be conducted using more texture modifiers to get a better understanding of the differences between hydrocolloids.
- A Temperature Sweep could be done to check how the products behaved at different temperatures, how the product acted when it was warm and how it acted when it started to become colder.
- In age care facilities, it’s desired to have products that can be stored for a longer period of time. The measurements could be performed several times over multiple weeks.
- The heating of the samples, before the measurements, was done at 95^{o}C for 20 min. This is a high temperature which could have caused the effects of oil to be destroyed in the heating. The same experiments could be performed by preheating the samples at lower temperatures.

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Appendix A

Datasheet – Modified Corn Starch (Farinex), produced by Avebe

Avebe

P.O. Box 15
9640 AA Veendam
The Netherlands

E-mail customerservice@avebe.com
www.avebe.com

General product information document

Farinex™ WM 55

Farinex™ WM 55 is an acetylated distarch adipate of waxy maize origin. It is a white to yellowish powder and free from objectionable odours. This product is intended for use in food.

Physical and Chemical Specification

Item		Value	Method complies with
Heavy metals	Arsenic (As)	<= 1.0 mg/kg	Atomic absorption method
	Cadmium (Cd)	<= 0.1 mg/kg	Atomic absorption method
	Mercury (Hg)	<= 0.05 mg/kg	Atomic absorption method
	Lead (Pb)	<= 0.5 mg/kg	Atomic absorption method
Sulphite (as SO_2) on an anhydrous basis		<= 10 mg/kg	ISO 5379
Moisture Content		140 mg/g	ISO 1666

- This product meets the requirements of Regulation (EU) No. 231/2012 on specifications for food additives (E1422).
- This product meets the requirements of the Food Chemical Codex (Food Starch Modified).
- This product meets the requirements of USA 21 CFR § 172.892 (Food Starch Modified).
- This product meets the requirements of the JECFA monograph on modified starch (Codex Alimentarius, INS 1422).

Microbiological Specification

Item	Value	Method complies with
Total aerobic mesophilic count	<= 10000 CFU/g	ISO 4833
Yeasts	<= 250 CFU/g	ISO 21527
Moulds	<= 250 CFU/g	ISO 21527
Enterobacteriaceae (1 g)	Absent	ISO 21528
Salmonella (25 g)	Absent	ISO 6579

Nutritional Properties

Item	Typical value per 100 g[1]	Item	Typical value per 100 g[1]
Energy	345 kcal /1460 kJ	Calcium	0.006 g
Protein	0.4 g	Chloride	0.01 g
Carbohydrates	86 g	Iron	0.001 g
Sugars	—	Magnesium	0.002 g
Fat	< 0.1 g	Phosphorus	0.03 g
Saturates	—	Potassium	0.005 g
Unsaturates (mono- and poly)	—	Sodium	0.03 g
Transfats	—	Vitamins	—

[1] All values are expressed in product as such at maximum specified moisture content (typical values, not a specification).
— Not present in significant amounts.

ref.no. 219108 version 01, issued March 2017, valid till March 2020

Avebe

General product information document

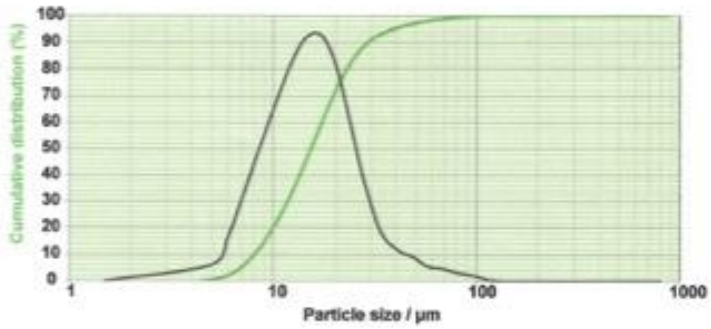
Shelf life and Storage conditions

Farinex™ WM 55 has a best before date of 2 years after the manufacturing date.
Store inside, cool and dry, in sound and well closed packaging. Protect from contamination. Do not store or ship together with odorous or toxic substances. It is advised however, to keep the storage time as short as possible, because the moisture content may change.

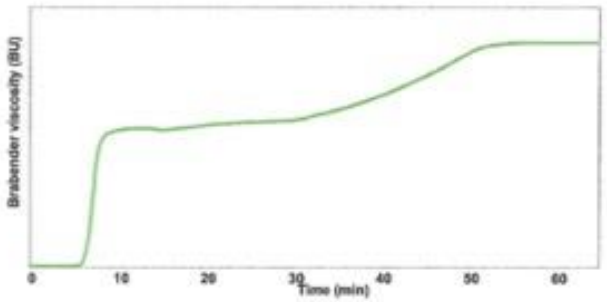
Additional Product Information

Bulk density (typical value, not a specification)
500 kg/m³

Particle size distribution (typical curve, not a specification)
Measured from dry sample (as is) and calculated as spheres



Brabender Viscosity graph



Viscosity
Concentration : 33 g product calculated on dry matter.
Procedure : With demineralised water the sample weight is filled up to a total weight of 500 g.
Brabender E-type; head 350 cmg, n= 75 min⁻¹

Brabender:	Slope	Ramp time (min:sec)	Temperature	Hold time (min:sec)
			50 °C	
	3.0 °C/min	15:00	95 °C	15:00
	-3.0 °C/min	15:00	50 °C	

Avebe

General product information document

Botanical Origin
- *Zea Mays*; maize

Allergens
Information about allergens is communicated via an allergen statement, which is available on request.

Dietary suitability
- Suitable for vegan, ovo-vegetarian, lacto-vegetarian and ovo-lacto vegetarian diets.
- Kosher and Halal certified.

Intended Use
- Food additive for use in food. It is recommended this product is used in accordance with Regulation (EC) No. 1333/2008 on food additives, or the General Standard of Food Additives (GSFA) of Codex Alimentarius or any other relevant legislation (see disclaimer).
- This product is in its available packaging variants not intended for retail sale.

Labelling advice
Consider the appropriateness of any labelling advice provided by Avebe, having regard to the intended use and local legislations.
- In the EU this product may be designated as modified starch on the consumer label, there is no need to mention an E-number. To mention maize as botanical origin of the starch is optional.
- In the USA this product may be designated as food starch modified on the consumer label.

Safety Data Sheet
The submission of a safety data sheet is not mandatory (Regulation (EC) 1907/2006). Relevant information to enable appropriate handling measures is communicated via a material safety data sheet in English language.

Food Safe Quality
- AVEBE operates in accordance with the general principles, requirements and procedures of food law and of food safety laid down in Regulation (EC) No. 178/2002.
- AVEBE ensures that food hygiene in accordance with Regulation (EC) No. 852/2004 is met during all stages of production, processing and distribution where this falls under her responsibility.
- AVEBE operates a management system accredited under ISO 9001.
- AVEBE conducts HACCP studies and identify relevant agro-chemical (including pesticides and contaminants), microbiological and physical risks to food safety associated with the production, processing and distribution of our products. We deploy adequate measures to mitigate the identified risks. Our employees are trained, our processes are monitored and our procedures are evaluated.

Logistical Information

Harmonised System (HS)
350510 Dextrins and Other Modified Starches.
Importing parties are responsible for customs declaration.

Certificate of Analysis / Certificate of Conformity
Each delivery is accompanied by a Certificate of Analysis/Certificate of Conformity.

General product information document

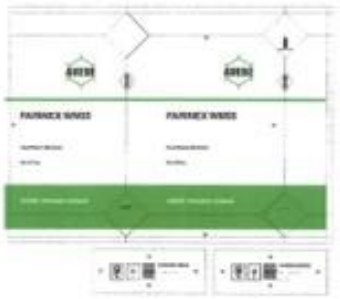
Packaging & Pallet combination

	Packaging	Pallet
1	Sealed multi layer paper bags	Wooden pallet of 100 x 120 cm

- All wooden pallets used by AVEBE are heat treated according to the International Standards For Phytosanitary Measures No. 15 (2009) (ISPM 15) developed by the International Plant Protection Convention (IPPC).
- The packaging is Food Contact Material (FCM) compliant (Regulation (EC) No. 1935/2004).

Labelling

Our **paper bags are**, amongst others, labelled with:
- Product name
- E/INS no.
- Net weight (W)
- Lot no.(L): ERP generated
- Best before end date (BB)



Our **sales units** are, amongst others, labelled with:
- Article no. AVEBE
- Article name
- Intended use
- E/INS no.
- Lot no.: ERP generated
- Pallet no.
- EAN no.
- Amount of primary packaging
- Production date
- Best before date
- Net weight

Avebe

P.O. Box 15
9640 AA Veendam
The Netherlands

E-mail customerservice@avebe.com
www.avebe.com

General product information document

Farinex™ WM 55

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Item		Value	Method complies with
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	Mercury (Hg)	<= 0.05 mg/kg	Atomic absorption method
	Lead (Pb)	<= 0.5 mg/kg	Atomic absorption method
Sulphite (as SO_2) on an anhydrous basis		<= 10 mg/kg	ISO 5379
Moisture Content		140 mg/g	ISO 1666

- This product meets the requirements of Regulation (EU) No. 231/2012 on specifications for food additives (E1422).
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- This product meets the requirements of USA 21 CFR § 172.892 (Food Starch Modified).
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Microbiological Specification

Item	Value	Method complies with
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Moulds	<= 250 CFU/g	ISO 21527
Enterobacteriaceae (1 g)	Absent	ISO 21528
Salmonella (25 g)	Absent	ISO 6579

Nutritional Properties

Item	Typical value per 100 g[1]	Item	Typical value per 100 g[1]
Energy	345 kcal /1460 kJ	Calcium	0.006 g
Protein	0.4 g	Chloride	0.01 g
Carbohydrates	86 g	Iron	0.001 g
Sugars	—	Magnesium	0.002 g
Fat	< 0.1 g	Phosphorus	0.03 g
Saturates	—	Potassium	0.005 g
Unsaturates (mono- and poly)	—	Sodium	0.03 g
Transfats	—	Vitamins	—

[1] All values are expressed in product as such at maximum specified moisture content (typical values, not a specification).
— Not present in significant amounts.

ref.no. 219108 version 01, issued March 2017, valid till March 2020

Appendix B

Datasheet – Agar, produced by Roeper

C.E. Roeper GmbH
Hans-Duncker-Str. 13, D-21035 Hamburg

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Internet www.roeper.de

ROEPER

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CERTIFICATE OF ANALYSIS

Article	10156	CERO Agar Agar Gelidium Type 8952 min. 750 gel	
Ref.	2556001	Batch	200200244
Production Date	02/2020	Retest Date	02/2024

Parameter	Method	Unit	Specification	Result
Assay	Regulation (EU)		threshold gel concentration max 0.25	conform *
Appearance	organoleptic		white to yellowish white, nearly odourless powder	conform
Solubility	FCC		insoluble in cold water, soluble in boiling water	conform
Gel strength (1,5%, 15h)	Nikkan-Kobe	g/cm²	min. 750	795
Loss on drying	gravimetric	%	max. 22.0	14.1
Ash on DM	gravimetric	%	max. 6.5	3.5
Acid-insoluble ash on DM	FCC	%	max. 0.5	max. 0.5
Insoluble matter	FCC	%	max. 1.0	conform
Starch	FCC		not detectable	not detectable
Gelatine and other proteins	FCC		not detectable	not detectable
Water absorption	FCC		max. 75 ml of water is obtained	passes test
Arsenic	FCC	mg/kg	max. 3	conform
Lead	FCC	mg/kg	max. 5	conform
Mercury	AAS	mg/kg	max. 1	conform
Cadmium	AAS	mg/kg	max. 1	conform
Total plate count	Ph. Eur.	cfu/g	max. 5 000	conform
Yeasts and moulds	Ph. Eur.	cfu/g	max. 300	conform
E. coli	Ph. Eur.		negative in 5 g	negative
Salmonella spp.	Ph. Eur.		negative in 5 g	negative

The specified test methods may differ from the actual methods used; but in the majority they are identical.

The analysed sample material meets the respective purity requirements of
231/2012/EU E 406

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* Conformity parameter; not measured for every lot but on monitoring basis. When tested results are within the specified limits listed.

Signature: Hamburg, 28.02.2020