Ready to eat meals enriched with omega-3 fatty acids

Product development and consumer study

Valgerður Lilja Jónsdóttir

Ritgerð til meistaragráðu
Háskóli Íslands
Matvæla- og næringarfræðideild
Námsbraut í Matvælafræði
Heilbrigðisvísindasvið

HÁSKÓLI ÍSLANDS

Omega-3 viðbættir tilbúnir réttir

Vöruþróun og neytendakönnun

Valgerður Lilja Jónsdóttir

Ritgerð til meistaragráðu í matvælafræði

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Thesis for the degree of Master of Science

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Ágrip

Markfæði (e. functional food) er heiti notað yfir þau matvæli sem innihalda næringarefni og/eða önnur efni sem hafa jákvæð áhrif á heilsu manna umfram önnur matvæli. Eins og til dæmis matvæli sem innihalda lífvirk efni, annaðhvort náttúrlega eða þeim hefur verið bætt í matvælin. Markaðurinn fyrir slíkar vörur er ört vaxandi í heiminum og virðist vera að neytendur sækist í auknu mæli eftir slíkum vörum til að bæta heilsu eða fyrirbyggja sjúkdóma. Markaðurinn fyrir ómega-3 viðbætt matvæli fer ört stækkandi í Evrópu, en á norrænum markaði eru sjávarréttir auðgaðir með ómega-3 eða öðrum sambærilegum lífvirkum efnum ekki þekktir. Rannsóknir hafa engu að síður sýnt að neytendur eru jákvæðir gagnvart auðguðum sjávarréttum, sérstaklega þar sem ómega-3 fitusýrum hefur verið bætt út í réttina.

Markmið þessa verkefnis var að þróa tilbúna rétti auðgaða með ómega-3 fitusýrum sem ætlunin er að markaðssetja sem hluta af nýrri framleiðslulínu og ná til heilsumeðvitaðra neytenda. Hluti af vöruþróuninni voru athuganir á gæðum og geymsluþoli réttanna. Ennfremur var markmiðið að rannsaka geðjun og viðhorf neytenda til þeirra rétta sem auðgaðir voru með ómega-3 fitusýrum í samanburði við samskonar rétti án viðbætts ómega-3 eftir endurtekna neyslu í fjórar vikur.

Vöruþróunin í verkefninu byggir á aðferðafræði State-gate vöruþróunarferilsins. Þrjár tilraunir voru gerðar til að auðga rétti með ómega-3 fitusýrum. Markmið tilraunar 1 sem var fortilraun var að kanna hvort og hversu mikið væri mögulegt að bæta af fiskiolíu í fiskibollur. Niðurstöður skynmats sýndu fram á að mögulegt væri að auðga fiskibollurnar með allt að 8% fiskiolíu. Í næstu tilraun voru þróaðar nokkrar gerðir rétta þar sem ómega-3 olíu (blanda af fiskiolíu og ólífuolíu) var bætt í réttina í því magni sem samsvara því að uppfylla ráðlagða dagsskammta af ómega-3 fitusýrunum. Mat á réttunum sýndi fullnægjandi árangur og því var farið í þriðju tilraunina þar sem framleiddar voru sex mismunandi frumgerðir af ólíkum tilbúnum réttum með og án ómega-3. Skynmat og efnamælingar voru notaðar til að kanna geymsluþol og gæði frumgerðanna sex eftir geymslu í frysti eftir 0, 3 og 6 mánuði. Jafnframt var rannsakað viðhorf og geðjun neytenda á frumgerðunum eftir endurtekna neyslu yfir fjögurra vikna tímabil. Þátttakendurnir fengu sex máltíðir á viku í fjórar vikur. Alls tóku 77 manns, 50 ára og eldri þátt í neytendakönnuninni og þar af fengu 50 manns rétti án ómega-3 og 27 þátttakendur fengu samskonar rétti sem auðgaðir voru með ómega-3. Í upphaf rannsóknarinnar svöruðu þátttakendur spurningum um fiskneyslu, fiskinnkaup, neyslu fæðubótarefna og hvort þeir skoði upplýsingar á umbúðum matvæla. Í fyrstu og fjórðu viku neytendakönnunarinnar svöruðu þáttakendur öðrum spurningarlista samhliða neyslu máltíðanna um geðjun á réttunum sex.

Auðguðum réttirnir höfðu hærra fituinnihald í samanburði við hefðbundnu réttina vegna ómega-3 olíunnar. Niðurstöður skynmats sýndu fram á að minnsta kosti 6 mánaða geymsluþol fyrir flesta réttina.

Að meðaltali keyptu þátttakendur í báðum hópum fisk einu sinni í viku og tilbúna fiskrétti fimm til átta sinnum á ári. Almennt geðjaðist þáttakendum vel að réttunum, bæði auðguðum og hefðbundnu. Einhver munur var á geðjun milli auðguðu réttanna og þeirra hefðbundnu, en mismikið eftir réttum. Geðjun á máltíðunum minnkaði ekki eftir endurtekna neyslu í fjórar vikur að undanskildum einum rétt.

Löngunin í að borða réttina var svipuð í viku 1 og viku 4 og þá sértsaklega þegar þátttakendur voru beðnir um að íhuga neyslu aftur eftir ákveðið langan tíma.

Niðurstöður rannsóknarinnar gefa til kynna að auðgun tilbúinna rétta með ómega-3 fitusýrum sé raunhæfur kostur en það sýndi sig jafnframt að ómega-3 olían hafði mismunandi áhrif á bragð réttanna og að sumar uppskriftirnar hentuðu betur en aðrar. Þessar niðurstöður þarf að hafa í huga við frekari þróun á tilbúnum vörum með viðbættu ómega-3 fitusýrum.

Abstract

Functional foods provide nutrition or health benefits beyond basic nutrition. The market for functional foods is one of the fastest growing in the world. Consumers increasingly seek for food products with known bioactivity either with natural or added ingredients as means to improve their health or prevent diseases. In Europe omega-3 enriched foods are fast growing food product category but ready to eat seafood products enriched with bioactive ingredients like omega-3 are not known in the Nordic market.

The aim of this project was product development of ready to eat products enriched with omega-3 fatty acids to be marketed as a part of new production line for health oriented consumers. The quality and shelf life of the products was aslo evaluated. Furthermore the aim was to study consumer liking of prototypes of omega-3 enriched ready to eat dishes in comparison to conventional dishes.

The product development was based on the Stage-gate principles. Three experiments in developing seafood dishes with addition of omega-3 oil were conducted. The aim in the first experiment that was a pre trial was to find out if and how much of fish oil could be added to fish cakes. Sensory evaluation showed acceptable results using up to 8% of fish oil. Next, several other types of dishes were developed with the amount of the omega-3 oil (blend of cod liver oil and olive oil) needed to fulfil the recommended daily dosage of omega-3. Evaluations of the dishes showed satisfactory results and in the third experiment, six different prototypes with and without the omega-3 oil were developed. Sensory evaluation and chemical analysis was used to evaluate the shelf life and quality of the prototypes after 0, 3 and 6 months of frozen storage. Consumer liking and experience after repeated consumption over four weeks of the six prototypes was studied. The participants received six meals every week over a four week period. Altogether 77 consumers, 50 years and older participated in the study, thereof 50 consumers received regular meals and 27 consumers comparable meals but enriched with omega-3 oil. Before the start of the consumer study, the participants answered a questionnaire about general fish consumption, purchase habits regarding fish, intake of supplements and if they looked at the labeling of food. In the first and fourth week, the participants answered questions about liking of the ready to eat dishes parallel to consuming the meals.

The enriched dishes had higher fat content compared to the conventional dishes due to the omega-3 oil. Sensory evaluation of most of the dishes showed that the products had a shelf life of at least six months.

On average participants in both groups in the consumer study bought fish once a week and ready to eat dishes 5-8 times per year. Generally, the meals were well liked, both the enriched and conventional meals. Some liking differences were noticed between the conventional and enriched meals, depending on the type of meals. The liking of the meals was not reduced with repeated consumption with the exception of one type of meal. Desire to consume the meals was similar in week one and four, especially when the participants were asked to consider consumption after extended period of time.

The results indicated that enrichment of ready to eat meals with omega-3 oil is a realistic option, but the flavour of the dishes is differently effected by the oil and some recipes appear to more suitable than other. This needs to be taken into consideration during further product development of convenience products enriched with omega-3 oil.

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Abbreviations

EPA	Eicosapentaenoic acid
DHA	Docosahexaenoic acid
ALA	α-Linolenic acid
WHO	World Helaht Organization
PV	Peroxide Value
TBARS	Tiobarbutic Acid Reactive Substance
TCA	Trichoroacetic
ANOVA	One Way Analysis of Variance
GLM	General Linear Models
GDA	Generic Descriptive Analysis
SD	Standard deviation

1 Introduction

Every day we can choose from wide variety of food from the shelf of the supermarkets and at restaurants. Although there are abundant of information for consumers about healthy food choices and recommendations given by authorities, food and lifestyle diseases are still increasing in the Western world. Cardiovascular diseases is one of these illnesses related to food and lifestyle and in 2011 it was one of the 10 leading causes of death in the world, causing nearly 17 million deaths (WHO, 2011). Consumption of the omega-3 fatty acids, eicosapentaenoic acid (EPA C20:5) and docosahexaenoic acid (DHA C22:6) can reduce cardiovascular risk in persons with high risk factors (Delgado-Lista et al., 2012). Omega-3 fatty acids have also been suggested to reduce risk of death from coronary heart diseases in healthy adults (Harris et al., 2008; Schmidt et al., 2000).

The main dietary sources of omega-3 polyunsaturated fatty acids are fish oils and fat fish such as salmon, herring and halibut but omega-3 can also to be found in other seafood like algae and krill. Marine omega-3 fatty acids are EPA and DHA. ALA (α-Linolenic acid) is also a source of omega-3 fatty acids which can be found in plants and nuts. It is considered essential to get the omega-3 fatty acids from food because they are not formed in the body (Trautwein, 2001). According to recommendations in the Nordic countries, it is desirable that 5-10% of energy intake is from polyunsaturated fatty acids, and 1% of the total energy intake should be omega-3 fatty acids (NNR, 2012). Other international organizations such as World Health Organization (WHO) and the European Food Safety Authority recommend that the omega-3 intake should correspond to 1-2% of daily energy and the sum of EPA and DHA should be higher than 250 mg per day (Agostoni, 2010; WHO, 2003) A survey of the diet of Icelanders revealed that the consumption of polyunsaturated fatty acids is 5.9% of the total energy and omega-3 fatty acids is 1.5% of the total energy (Þorgeirsdóttir et al., 2011). Males and females did not differ with regard to omega-3 intake, but there were differences by age groups. Men and women aged 18-30 years receive smaller amount of polyunsaturated fatty acids and omega-3 compared to other age groups (5.7% of polyunsaturated fatty acids and 1.2% of omega-3). A high standard deviation indicates that some people are probably getting too little of omega-3. Also if we look at fish consumption and omega-3 intake in the United Kingdom for example, intake is below recommendations (P. M. Kris-Etherton et al., 2000; Sanders, 2000).

Relationship between foods and health or diseases for example omega-3 fatty acids and cardiovascular disease and probiotics and intestinal tract health, has led to development of so called functional foods and given food manufacturers an opportunity to help people fulfilling appropriate intake of healthy ingredients (German et al., 1999; Niva, 2007). Consumers increasingly seek for food products with known bioactivity either natural or with added ingredients as means to improve their health or prevent diseases. The market for these types of products is one of the fastest growing markets in the world today (Siró et al., 2008).

Worldwide there are examples of omega-3 enriched foods like bread and bakery products, milk and dairy products, spreadable fats, eggs and egg products, meat and poultry products and juices and soft drinks (Lane et al., 2014). Enrichment of food with omega-3 fatty acids is a multidisciplinary challenge like C. Jacobsen (2010) pointed out in her study. Things need to be considered are for example

oxidation of the fatty acids, shelf life, consumer acceptance, acceptable sensory properties and bioavailability of the omega-3 fatty acids in the food product developed.

1.1 Functional food

Functional food originated in Japan in the 1980 when the industry used the term functional food over fortified foods that were supposed to give certain health benefits. Today Japan is the only country that has regulatory procedures for functional foods. The term functional food has though not been unitarily defined and several definitions can be found for functional food (Roberfroid, 2002; Siró et al., 2008). In general a functional food is defined as any food, or food component similar to conventional foods that provides nutritional or health benefits like prevention of diseases, beyond basic nutrition (Kaur et al., 2011). Functional food could for example be food enhanced or enriched with bioactive compounds or nutrients like vitamins, fibers and antioxidants. As Kaur et al. (2011) pointed out in his review of functional foods, it is possible to sort or classify functional food into several groups depending on how the food is modified, it could be fortified, enrichment, genetic manipulation and feeding of animals.

The market for functional food is one of the fastest growing markets in the world today and was in 2000 estimated to be 33 billion US$ (Hilliam, 2000) and expected to reach 130 billion US$ in 2015 (Kaur et al., 2011). No accurate numbers were found for the value of the market today. The market for functional food is marginally smaller in Europe compared to the American and Japanese markets (Tino Bech-Larsen et al., 2007). Slower development of functional food in the Europe market compared with the rest of the Western world might be explained by that European consumers in general seem to be more suspicious with novel food, food processing methods and enriching food with additional ingredients (T. Bech-Larsen et al., 2003). One of the ways to market functional food is with good promotion of the health benefits, like authorized claims based on scientific evidence.

1.1.1 Nutrition- and health claims

Tino Bech-Larsen et al. (2007) point out that legislation about health claims regarding functional food were inconsistent between and in the European countries. This made marketing of functional food difficult but in the year 2007 a new legislation was implemented by the European Union (EU) (Regulation on nutrition and health claims no. 1924/2006) on nutrition and health claims on foods. Producers of functional food who want to market their products with claims can use permitted health claims that are to be found in the EU register of nutrition and health claims on foods, as long as the presentation and wording of the claim corresponded to clause of the regulation. If functional food or any foods that contain added amounts of omega-3 fatty acids or other functional ingredients in the amount that meets the requirements of the regulations they can be labelled with permitted nutrition and health claims, which may be a good way to advertise the product (Regulation on nutrition and health claims). Today four nutrition- and health claims are authorized for omega-3 fatty acids in the EU register, three for EPA and DHA and one for ALA. Studies on functional food have however shown that product quality is the most important factor in marketing and selling functional food (Tino Bech-Larsen et al., 2007). It has also been shown that though the health claim on food products communicates the health effect to consumers, does it not necessarily make the product more

appealing from consumer perspective (Lahteenmaki, 2013). Thus, successful functional food development requires understanding of consumers' demands.

1.1.2 Omega-3 enriched food

Omega-3 fatty acids have not only been positively linked to cardiovascular diseases but also to reduction of inflammatory disease, improvement of brain development and function and mental health (Ruxton et al., 2004). In USA and Europe omega-3 enriched foods is fast growing food product categories (Sloan, 2006) but ready to eat seafood products enriched with bioactive ingredients like omega-3 are not known in the Nordic market. However, other products with functional ingredients are available, especially dairy products such as Benecol containing plant phenol with cholesterol lowering function, LGG with prebiotic effect improving gut health and Valio Evolus® containing bioactive tripeptides with blood pressure lowering effect (Siró et al., 2008).

Cod and haddock are a lean fish species that means they contain less polyunsaturated fatty acids like omega-3 compared to fat species, such as salmon and herring (Penny M Kris-Etherton et al., 2003). Therefore addition of omega-3 fatty acids into lean fish based products could be a way for producers to enhance the content of these fatty acids up to level fulfilling recommendations.

Consumer's views of health products and functional foods have been studied in recent years (Grunert et al., 2009; Siró et al., 2008). The findings showed that consumers were positive towards enrichment with bioactive ingredients such as omega-3 fatty acids. Preliminary studies at Matís have shown that it is possible to increase the content of omega-3 fatty acids in fishcakes without negatively affecting the flavour (Unpublished data).

1.2 Product development

Product development is known by many names like innovation, novel design etc. It all involves the creation of an idea, service or a product, either a new one or an already existing product and the process from the idea to the market. Actually there are rarely entirely new products involved in product development and most of the time, the product development deals with modification or improvement of an existing product.

Product development involves any change in a product and to minimize time and cost of product development many processes or systematic methods have been developed to enable companies to undertake product development. The overall process of product development often includes different steps, starting with idea generation, then idea screening, concept development and testing, marketing strategy development, business analysis, development of the product or the idea, market testing and commercialization or scoping, product definition and validation are all common steps. Concept testing includes consumers survey's and tests, for example home use test (Earle et al., 1998). Cooper introduced a method in product development called Stage-gate principle (Cooper, 2006) where the emphasis is put on consumer's opinions and where the consumer's ideas are incorporated in the product development process.

In the Stage-Gate are seven key principles which are developed from studies on best practices in product development. The first and the main principle is custumer focused, it's about highlighting the

consumer's views. Other main principles are; 2) Heavy front-end homework before development begins where the emphasis is to examine the market; 3) Spiral development where the emphasis is to create prototype of the product and explore consumer's reactions to it and detailed estimate of whether the product will return a profit; 4) A holistic approach where the emphasis is to create effective cross functional teams working on bringing the product to market fast; 5) Metrics, accountable teams, profit/loss report for continuous learning. Where measurements are performed to measure the new product success and if weakness or problems come up with the product they are fixed; 6) Focus and portfolio management. Lean, scalable, and adaptable Stage – Gate process where the main emphasis is to identify the good ideas from the bad ones and remove the weak or bad ones through gates; 7). The last principle is three factors that are all about adapting certain gates where decisions are made. Each principle in this process is also a gate and by the gates the team decides whether to continue with the product or not (Cooper, 2006).

1.3 Oxidation of omega-3 enriched products

Lipid oxidation is one of the most common and important factor limiting the shelf life and quality of seafood products (Rustad, 2009). Marine oil products are especially susceptible to oxidation because of their high content of unsaturated omega-3 polyunsaturated fatty acids aptitude to oxidation. Reaction products from the lipid oxidation have a negative effect on the sensory properties of fish products, commonly described as rancid odour and flavour (Jacobsen, 1999). The oxidation also forms free radicals which have negative health effects.

The volatile, secondary oxidation products from lipid hydroperoxides decomposition, especially those that originate from omega-3 PUFAs are components that have a low odour threshold and therefore have a negative impact on the sensory quality of the food even in low concentrations (Frankel, 2005). Omega-3 enriched food might therefore be difficult to handle due to consequent off-flavours. Different factors can affect the rate of lipid oxidation like oxygen enhance the oxidation, the oil quality can have effect on the oxidation stability of the product, metal ions are oxidation catalyst in many food products, temperature can increase oxidation if too high and antioxidants for example tocopherols can retard or inhibit the oxidation. Therefore in production of omega-3 enriched products all these factors have to be kept in mind but they can all have different effects in different food systems (Jacobsen, 2008). In the literature lipid oxidation evaluations has been described in different ways, including modification occurring during shelf life and also take into account physical, sensory and chemical aspects of food products. The most common methods are quantification of peroxide value, thiobarbituric acid reactive substances (TBARS) and sensory descriptive analysis (Nguyen et al., 2012).

1.3.1 Peroxide value (PV)

The method of measuring peroxide value is used to evaluate the primary oxidation in products. For determination of peroxides (PV) in foods several different methods are available for different food materials and the PV measurements vary both between the methods used and how the procedure is performed (Frankel, 2005). When PV is used solely to determine the oxidation level it has to be kept in mind that after the initiation phase the level of primary oxidation products increases and passes

through a maximum and can therefore be misleading. Also when measuring the PV it is important to know the history of the food measured to interpret the results of PV (Rustad, 2009).

1.3.2 Thiobarbituric acid reactive substances (TBARS)

Determination of secondary products such as thiobarbituric acid reactive substances (TBARS) is usually combined with determinations of PV as peroxides are unstable and are rapidly transformed into secondary oxidation products (Pettersen, 2006). As for PV there are many different methods available and the TBARS measurements vary both between the methods used and how the procedure is performed. For example results of TBARS measurements for different food with the same level of oxidation can vary significantly ("AOCS Official Method Ti 1a-64," 1995; Frankel, 2005; Nawar, 1996).

1.4 Sensory evaluation

Sensory analysis is one of the most important method available today to evaluate the quality of food. Sensory evaluation is a systematic assessment of odour, flavour, appearance and texture of food by the human senses of vision, smell, taste, touch and hearing. The methods used in the sensory evaluation depend on the aim of the sensory evaluation. Different purposes of sensory evaluation are for example quality control, product development, shelf life studies, research and consumer surveys (Meilgaard et al., 2006).

Sensory analysis can both be objective and subjective. Subjective tests are usually used for consumer testing to measure the attitude and emotional response of the consumer toward the product where untrained human beings usually consumers answer subjectively. Scalar method are often use where consumer degree of liking and disliking is estimated on a seven- or nine- point structured hedonic scale (Martinsdottir et al., 2008). Objective tests include discriminative and descriptive sensory tests. Both of these tests are analytical measurement of the intrinsic quality of products. In objective test a trained panel, usually 6-12 penellists objectively describes the attributes of products using defined sensory descriptors (Nollet et al., 2011). The trained panel is specially selectd group of people that have been passed through several sensory tests and trained according to ISO standards (Meilgaard et al., 2006).

1.4.1 Sensory evaluation in product development

A part of product development is consumer's studies where the aim is to test the product and get feedback from target consumers on the product. Interaction with consumers can be made with home use tests, central location test, focus groups etc. Home use tests are a good tool in early product development to assess product attributes, preference, and performance under real or actual use conditions. Home use test have also been used to study liking after repeated in-home consumption. The pleasantness after repeated consumption can give different results from laboratory sensory analysis. Home use test, central location test and focus groups often give results from testing of small food sample in relatively short time of exposure period. In addition marketing information can be obtained like usage patterns, and other helpful information's for marketing the product (Zandstra, De Graaf, Mela, et al., 2000). Information regarding repeat-purchase habits may be obtained from the consumers (Resurreccion, 1998).

In product development both objective and subjective sensory analysis are used. Quantitative Descriptive Analysis (QDA) is a good objective method used to obtain a complete sensory description of a product, including detailed description of all aspects regarding appearance, odour, flavour and texture (Martinsdottir et al., 2008). Descriptive tests are suitable for product development since they require definition, evaluation and understanding of sensory characteristics of the product which give a data that decision can be made on (Carpenter et al., 1999; Meilgaard et al., 2006).

1.4.2 Sensory evaluation in shelf life studies

The aim of shelf-life studies is to estimate the time food products can be kept at some given storage condition. Among questions sensory evaluation of products can answer regarding shelf-life is how long the product can be kept before unacceptable changes sensory quality are detected, how the product changes during storage and which changes occur in sensory quality (Carpenter et al., 1999)

2 Aim

This master thesis was carried out under the umbrella and as a part of the Nordic project Enriched Convenience Seafood products funded by Nordic Innovation**.** The aim of the Nordic project was to increase the value of ocean based raw materials, reach new seafood consumer groups and increase market share of the companies involved as a step forward for production of enriched seafood dishes for targeted consumer groups. Seafood dishes enriched with bioactive compounds from the ocean, such as seaweed, fish proteins and fish oil were developed to meet market demand. In the project the stability and bioactivity of ingredients for use in consumer products were studied and the effect of enrichment on stability and quality of the seafood products. Acceptance of the concepts and the prototypes in consumer studies in the Nordic market were studied. The fatty acid profiles of the blood of a certain group of consumers using enriched seafood dishes for period of time were measured to be able to use to calculate individual protection of persons against lifestyle diseases. This innovative seafood development project based on collaboration between a fish processing company, ingredient companies and food research institutes with emphasis on consumer oriented product development, consumer testing and marketing. The coordinator of the project was the Matís ohf. / Icelandic Food and Biotech R&D. Other R&D participant was VTT Technical Research Centre of Finland. The seafood companies participating were Grímur Kokkur ehf Seafood producer, Iceland and Hätälä Oy, Seafood producer, Finland. The ingredients companies were BioActive Foods, Norway, Norður (North) ingredients producer Iceland and Marinox, Iceland.

The aim of this thesis was product development of omega-3 enriched ready to eat meals in a new production line for health oriented consumers and to evaluate the quality and shelf life of the products with sensory- and chemical analysis. Furthermore to study consumer liking of prototypes of enriched ready to eat dishes in comparison to conventional dishes and to study liking and experience after repeated consumption over four weeks. The study was carried out with 99 participants in two sessions, one during the spring and other in the autumn in 2013. The work was carried out in co-operation with the Unit for Nutrition Research, Landspitali University Hospital & Faculty of Food Science and Nutrition, University of Iceland.

3 Materials and methods

3.1 Product development of convenience products enriched with omega-3 oil

The product development in the project was based on the Stage-Gate® principles (Cooper, 2006). The development was carried out in three experiments (figure 1). The first step was a pre-trial to decide how much omega-3 oil could be added to the products without negatively affecting the sensory quality, which was done in an experiment with fish cakes and cod liver oil. The next step was to try comparable amount of omega-3 oil in other dishes, and then these dishes were further developed. These steps are described in sections 3.1.1 – 3.1.3.

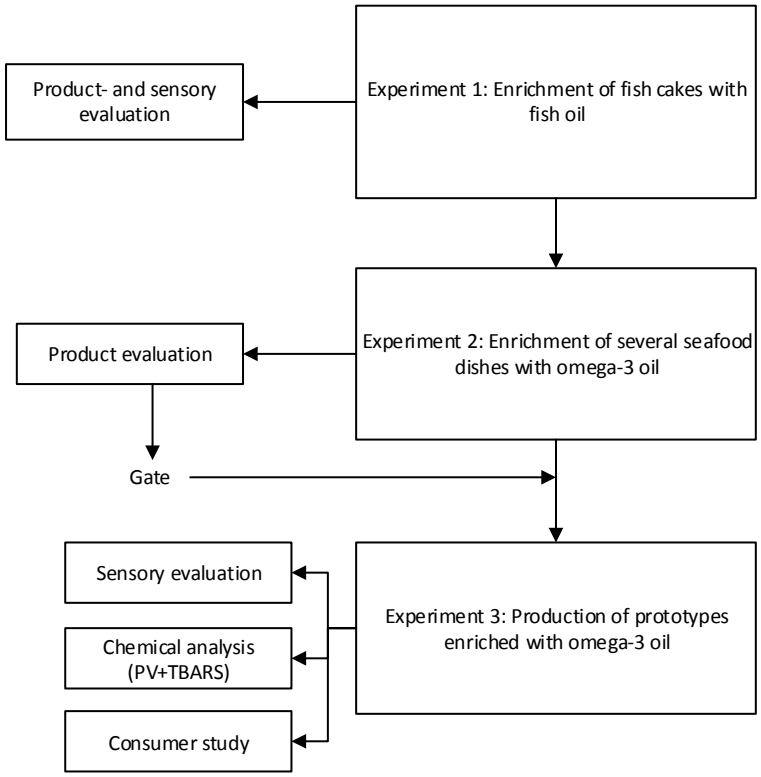

Figure 1 Process flow of the product development

3.1.1 Experiment 1: Fish cakes enriched with cod liver oil

To estimate how much fish oil could be added to fish cakes without negatively affecting sensory quality, an experiment was conducted with fish dough (Appendix 1) sent from the seafood producer. The dough was produced the day before arrival and the experiment was conducted the same day. Regular cod liver oil (List of ingredients. Appendix 1) was used and mixed into the dough in different amounts (Table 1). After mixing the fish oil into the dough it was let wait for 10-15 minutes at room temperature before fish cakes were made of it. Each fish cake was around 50 grams and in total 20 fish cakes was made for each group (Table 1). The cakes were heated at 175°C in oven for 20 minutes and then after heating let wait again for 30 minutes at room temperature and in cooler (0-4°C) for five minutes. The fish cakes were then packed in regular plastic sample bags (not vacuum) and

stored in refrigerator (0-4°C) and freezer (-18°C) for two days. Two days later the fish cakes were evaluated by a sensory panel. The fish cakes were kept at room temperature for three hours before heating. Fish cakes stored in refrigerator were heated directly.

Table 1 Description of sample groups of fish cakes used in Experiment 1.

Group	Fish oil	Dough
Control	0 g	1000 g
4% cod liver oil	40 g	960 g
6% cod liver oil	60 g	940 g
8% cod liver oil	80 g	920 g

3.1.2 Experiment 2: Addition of omega-3 oil into fish dishes

The products used in experiment 2 were produced at the production line at the seafood producer facilities. In this experiment we used omega-3 oil not cod live oil like in experiment 1. This was because we wanted to use the omega-3 oil provided by the ingredients supplier in the project. The aim was to study if 6% of the omega-3 oil could be used in different recipes. Using five existing recipes and one new (Table 2) (Appendix 1). The purpose was to decide which products were most feasible to continue with in the production of prototypes enriched with omega-3 oil. The omega-3 oil used is a confidential blend of cod liver oil and olive oil provided by ingredients producer in the Nordic project (Table 16, Appendix 2).

First, the omega-3 oil was mixed with freshly made fish in white sauce (e. fish Pie) and fish dough. The fish in white sauce was then packed into aluminum box and plastic bag (vaccum), cooled (<4°C) and stored in the refrigerator (0-4°C). Fish cakes were made from the fish dough fried in a pan with canola oil after 15 minutes, cooled down to <4°C, packed into plastic bags (vaccum) and stored in the refrigerator (0-4°C).

A new product called Arctic char fish cakes was developed and produced. The fish dough was mixed with the omega-3 oil, formed into cakes and then fried, cooled, packed and stored in the refrigerator. Finally, new products made of haddock and garlic-, lobster-, and curry sauce was produced. The oil was mixed into the sauce. After mixing the oil into the dishes were packed into aluminum box and plastic bags (vaccum), cooled down to <4°C and stored in the refrigerator (0-4°C), At the end of the production day, all the products were taken out of the refrigerator and quik frozen. The same day the dishes were transported to Matís, Reykavík for product evaluation the next day.

Table 2 Description of sample groups in experiment 2. The one market with ǂ is the new recipe.

Sample	Fish oil	Dough
Fish in white sauce (Is. Plokkfiskur)	56.8 g	1000 g
Fish cakes (Is. Fiskibollur)	56.8 g	1000 g
Arctic char fish cakes (Is. Bleikjubollur)ǂ	56.8 g	1000 g
Haddock in lobster sauce (Is. Ýsa í sósu)	56.8 g	1000 g
Haddock in curry sauce (Is. Ýsa í sósu)	56.8 g	1000 g
Haddock in garlic sauce (Is. Ýsa í sósu)	56.8 g	1000 g

3.1.3 Experiment 3: 12 prototypes with and without omega-3 oil

In this experiment, six prototypes of convenience meals were produced. In total, 12 products were produced: six convenience meals with omega-3 oil enrichment and comparable meals without enrichment with omega-3 oil (Table 3). All dishes were produced at the production facilities of the seafood producer. The products were analyzed with sensory evaluation during storage up to six months and simultaneously oxidations measurements, peroxide values, TBARS and consumer study were conducted.

Table 3 Samples in experiment 3 and sample code for each samples

Sample	Sample code	Sample	Sample code
Fish in white sauce	WHITE	Fish in white sauce with omega	WHITE-O3
Gratinated haddock with broccoli	BROCC	Gratinated haddock with broccoli with omega	BROCC-O3
Haddock in curry sauce	CURRY	Haddock in curry sauce with omega	CURRY-O3
Haddock in lobster sauce	LOBST	Haddock in lobster sauce with omega	LOBST-O3
Fish cakes	FISHCAKE	Fish cakes with omega	FISHCAKE-O3
Vegetable cakes	VEGCAKE	Vegetable cakes with omega	VEGCAKE-03

3.3 Sensory evaluation

3.3.1 Product evaluation

The prototypes from experiment 1-3 were evaluated using product evaluation. Five trained panellist from the sensory panel at Matís evaluated the fish cakes. They described the appearance, smell, taste and texture of the products but did not evaluate using a scaling syrstem. The dishes were kept frozen until thawed at room temperature four hours before heating and served to the panelists

3.3.2 Sensory analysis

The dishes from experiment 1 and 3 were evaluated in sensory evaluation using generic descriptive analysis (GDA) (Stone and Sidel, 2004). A trained sensory panel evaluated the samples by defined sensory attributes (table 4 and 5). Panelists, who all were trained according to ISO 1993 and had experience in the method, participated in the sensory evaluation. The sensory attributes were seven in experiment 1 and 17 in experiment 3 (table 4 and 5). Each attribute was evaluated by describing the intensity of each attribute for a given sample using an unstructured 15 cm line scale that was converted to 0-100 in data analysis. The attributes were defined and described by the sensory panel during training sessions.

All samples were coded with three-digit numbers and served in a different order to the panellists. A computerized system (FIZZ, Version 2.0, 1994-2000, Biosystèmes) was used for data recording.

Sensory analysis of fish cakes enriched with fish oil (experiment 1)

The aim of the sensory analysis was to quantify the odour, flavour and texture attributes of the fish cakes that could be related to the enrichment and to estimate the effects of storage time during refrigerated and frozen storage on sensory characteristics.

For evaluation fish cakes were heated at 180° C for 6 minutes. Then they were taken out from the oven and cut into quarters and each sample was one square (~ 10g). The samples were placed in small aluminum boxes and then further heated in the oven for 2 minutes. Samples were served hot in aluminum box with a plastic lid and four samples were evaluated during each sensory session.

Table 4 Description of GDA sensory attributes for fish cakes in experiment 1

Sensory attribute	Scale	Description
Rancid odour	None II Much	Rancid odour
Rancid flavour	None II Much	Rancid flavour
Dried fish flavour	None II Much	Dried fish flavour
Salt	None II Much	Salty flavour
Umami	None II Much	Umami flavour
Bitter	None II Much	Bitter flavour
Fatty mouth feel	None II Much	Fatty mouth feel

Sensory analysis of the 12 prototypes (experiment 3)

All the 12 dishes were evaluated by sensory evaluation at the beginning of storage and after three and six months of storage.

For evaluation dishes were taken out of freezer and kept at room temperature for three hours before heating. The dishes were heated at 180°C until core temperature had reached 72 °C. Samples of each dish about 50g were placed in small aluminum box and served warm in aluminum box with a plastic lid. Four samples were evaluated at a time.

Table 5 Description on GDA sensory attributes for Fish in white sauce*, Gratinated haddock with broccoli*, Fish cakes*, Fish in curry- and lobster sauce, and Vegetable cakes***. If not marked with * than the description apply for all the dishes otherwise it is only apply for that dish.**

Sensory attribute	Scale	Description
Olive oil odour	None II Much	Olive oil odour
Fish oil odour	None II Much	Fish oil odour
Rancid odour	None II Much	Rancid odour
Cold storage odour	None II Much	Frozen storage- cold storage odour
TMA odour*,**	None II Much	TMA, reminds of dried salted fish, amine
Salt	None II Much	Salty flavour
Pepper	None II Much	Pepper flavour
Olive oil flavour	Nothing II Much	Olive oil flavour
Fish oil flavour	None II Much	Fresh fish oil, fresh liver, not rancid
Rancid flavour	None II Much	Rancid flavour
Cold storage flavour*,**	None II Much	Cold storage flavour (of the fish*)
TMA*,**	None II Much	TMA flavour of fish /TMA, reminds of dried salted fish **
Softness	Firm II Soft	Texture of the fish, softness of the first bite/ Fist bite**;***
Juice	Dry II Juicy	Texture of the fish, dry: pulls juice from the mouth **,***
Tenderness*,**	Tough II Tender	Texture of the fish, when you have chewed several times
Rubber like*,**	Little II Much	Texture of the fish, rubbery,**
Fatty mouth feel	None II Much	How much fat adhering to the mouth after tasting

3.4 Storage study in experiment 3

The prototypes from experiments 3 were evaluated in storage study by sensory evaluation and oxidation measurements (PV and TBARS). These measurements were carried out for all the 12 prototypes at the beginning of the storage, after 3 and 6 months of frozen storage at -18°C.

3.4.1 Chemical- and fatty acids analysis

The following chemical analyses were carried out by accredited methods at Matis chemical laboratory. The chemical analyses were carried out on the 12 prototypes from experiment three. These

measurements were conducted to know the water content for calculation of the oxidation measurements (PV and TBARS). Also to see how the enrichment with the omega-3 oil would affect the chemical composition.

Measurements of water content

Water content. AE 4. The sample is heated in an oven at 103°C+/-2 °C for four hours. Percentage of moisture corresponds to the weight loss (ISO 6496, 1999).

Measurements of proteins

Protein. AE 3. The sample is digested in sulphuric acid in the presence of CuSO4 as a catalyst. There after the sample is placed in a distillation unit, 2400 Kjeltec Auto Sampler System. The acid solution is made alkaline by use of a NaOH solution. The ammonia is distilled into boric acid which is then titrated with H_2SO_4. The nitrogen content is multiplied by factor 6.25 to obtain % crude protein (ISO 5983, 2005).

Measurements of fat with Soxhlet method

Fat. AE 1. The sample is extracted with petroleum ether, boiling range 40-60°C. The extraction apparatus is 2050 Soxtec Avanti Automatic System (AOCS, 1997).

Measurements of ash

Ash. AE 5. The sample is ashed at 550°C for 3 hours, and then residue weighed. (ISO 5984, 2002)

Measurements of salt

Salt (NaCl). AE 2. Soluble chloride is extracted from the sample with water. Upon addition of nitric acid, the solution is titrated with silver nitrate and the end point determined potentiometrically (AOAC, 2000).

Fatty acids analysis

The first step in fatty acids analysis is fat extraction based on Bligh and Dyer (Bligh and Dyer, 1959). The second step involves methylation based on AOCS Official Method Ce 1b-89 with minor adjustments. The fatty acid methyl esters (FAME) were then separated on a Varian 3900 GC equipped with a fused silica capillary column (HP88, 100 m x 0.25 mm x 0.20 µm film), split injector and flame ionization detector fitted with Galaxie Chromatography Data System, Version 1.9.3.2 software. The oven was programmed as follows: 100 C for 4 min, then raised to 240 C at 3 C/min and held at this temperature for 15 min. Injector and detector temperature are 225 C and 285 C, respectively. Helium is used as a carrier gas at the column flow 0.8 mL/min; split ratio, 200:1. The programme is based on AOAC 996.06. The peaks in the chromatograms were identified by comparison with known fatty acid methyl ester standards (Sigma Chemical Co, Ltd).

3.4.2 Peroxide value method (PV)

Lipid hydroperoxides were determined with a modified version of the ferric thiocyanate (Santha and Decker, 1994). Total lipids were extracted from 5.0 g of samples with 10 mL ice-cold chloroform:methanol (1:1) solution, containing 500 ppm BHT to prevent further peroxidation during the extraction process. Sodium chloride (0.5 M) was added (5.0 mL) in to the mixture and homogenize at maximum speed for 10 seconds (Ultra-Turrax T-25 digital, IKA, Germany) before centrifuging at 2350

x g for 5 min at 4 °C (Model TJ-25, Beckman Coulter, USA). The chloroform layer was collected (500 µL out of 3.0 mL) and completed with 500 µL of chloroform:methanol solution. A total amount of 5 µL of ammonium thiocyanate (4 M) and ferrous chloride (8 mM) was finally added. The samples were incubated at room temperature for 10 min and read at 500 nm (Sunrise, TECAN, Austria). A standard curve was prepared using cumene hydroperoxides. The results were expressed as mmol lipid hydroperoxides per g of sample.

3.4.3 Thiobarbituric acid reactive substances method (TBARS)

A modified method of Lemon (1975) was used for measuring TBARS. A sample (5.0 g) was homogenized with 5.0 mL of trichloroacetic acid (TCA) extraction solution (7.5% TCA, 0.1% propyl gallate and 0.1% ethylenediaminetetraacetic acid mixture prepared in ultra-pure water) using a homogenizer at maximum speed for 10 seconds (Ultra-Turrax T-10 basic, IKA, Germany). The homogenized samples were completed with 5.0 mL TCA extraction solution and centrifuged at 9400 *x g* for 15 min (Model Z323K, Hermle laboratories, Germany). 0.5 mL supernatant was collected and mixed with the same volume (0.5 mL) of thiobarbituric acid (0.02 M) and heated in a water bath at 95°C for 40 min. The samples were cooled down on ice and immediately loaded into 96-wells microplates (NUNC A/S Thermo Fisher Scientific, Roskilde, Denmark) for reading at 530 nm (POLARstar OPTIMA, BMG Labtech, Offenburg, Germany). A standard curve was prepared using tetraethoxypropane. The results were expressed as µmol of malomaldehyde diethylacetal per kg of samples. (Lemon, 1975).

3.5 Consumer study

3.5.1 Study design

This was a four-week consumer study where consumer experience and liking of the meals (enriched dished compared to conventional dishes) was studied. The participants in the consumer study were randomized into two groups as shown in table 6. Group 1 (n = 38) was provided daily with 1.75 g EPA and DHA in the form of ready to eat meals enriched with omega-3 oil, group 2 (n = 61) was a control group. The participants received six ready to eat meals each week over the four weeks, either regular or enriched ready to eat meals depending on group (Table 6). The meals were four different fish dishes with sauce, fish cakes and vegetables cakes. Each portion weighed 200 g (Table 3). The same dishes were enriched with 5.68 g of omega-3 oil per 100 g. The meals were produced by the seafood producer. All the dishes were frozen and kept frozen until cooking or heating.

Table 6 Definition of diet groups in the consumer study

	Meals
1.Group	Enriched ready to eat meals
2.Group	Regular ready to eat meals

3.5.2 Participants

Participants were recruited through advertisements via internet, email lists at the University of Iceland and advertisements published in regional health care facilities. Inclusion criteria were to be 50 years or older and regular consumption of fish or fish meals. The exclusion criterion was a previous record of digestive disease which could interfere with the digestion or absorption of dietary fat. The aim was to get in total 90 participants, 99 participants started the consumer study.

The study was approved by the National Bioethics Committee (VSNb201302008/03.07) and was notified by the Data Protection Authority (S6241/2013). All persons gave their informed consent prior to their inclusion in the study.

3.5.3 Procedure

Data collection was conducted during the period of May – July 2013 and again September – October 2013. Each participant consumed six dishes six days a week over four weeks. They were allowed to consume the meals at any time of the day and anywhere they wanted but only one dish per day. The dishes were handed out to the participants in four deliveries, one in each week and the participants had to pick up the dishes. In each delivery the participants got six dishes. In the first and fourth delivery the participants also received questionnaires, at the end of the first and the fourth week the participants had to hand in the completed questionnaires. The delivery of meals and all the meeting with the participants took place at the facilities of the Unit for Nutrition Research, Landspitali University Hospital & Faculty of Food Science and Nutrition, University of Iceland in Kopavogur. The two master's student in the project along with Dr Alfons Ramel and a nurse met the participants.

3.5.4 The questionnaire

The participants received two questionnaires. In the first meeting of the consumer study (at the beginning of the study), they answered a questionnaire about general fish consumption and purchase habits, intake of supplements, use of information on food products (Appendix 3). For data treatment, the 7-point category scale was converted to continues scale according to Honkanen et al., (2005): Never 0.0; 1-4 times per year 0.05; 5-8 times per year 0.12; Monthly 0.25; 2-3 times per month 0.625; 1x per week 1; 2 times a week 2; 3-4 times a week 3.5; Daily/almost daily 6.5. And for the quest about consumption of supplements: Never 0; Less than monthly 0.05; Monthly 0.25; 2-3 times per month 0.625; 1x per month 1; 2 times a week2; 3-4 times a week 3.5; daily/almost daily 6.5; more than 1 time per day 7.

The second questionnaire was designed around the meals consumed. The participants answered this questionnaire during consumption in the first and last week of the consumer study (week 1 and 4) at their homes parallel to consuming the meals (Appendix 4). The questionnaire was based on two similar studies (Zandstra, de Graaf, & van Trijp, 2000; Zandstra et al., 2004) and a questionnaire by Einarsdóttir, (2008). For each meal the participants were asked three questions before consumption of the meals: the feeling of hunger; desire to eat the food and how interesting they thought the taste of the meal was (Zandstra et al., 2000). After or during consumption the participants were asked about liking of the dish (on a 9-point hedonic scale). The participants also had the opportunity to answer an

open-ended question about if there was anything they liked or disliked regarding the dish they were consuming. After consumption the participants were asked how much of the dish they consumed (Zandstra et al., 2000), if they desired to eat more of the meal (Zandstra et al, 2004) and probability of purchasing the meal. The participants also answered three questions about the meal preparation. Following were questions about boredom regarding consumption of the meal and how they liked the appearance, taste and texture of the meal (Zandstra et al., 2000). The participants were asked to write down the time of consumption and to describe cooking methods and what or if they had side dishes. In the end they were asked about their state of feeling after consuming the dish (Einarsdóttir, 2008) and desire to consume the dish again after 3 days, 1 week, 2 weeks and one month (Zandstra et al., 2004). At the end of the week they were asked additional remarks like if there were something that happened that led to that they couldn't follow the plan and also they were asked to rank all the dishes they had consumed that week.

3.6 Data analysis

Statistical analysis were conducted in the statistical programme SPSS to study significant difference between groups and weeks (t-test with the significance level set at 95% ($p < 0.05$)) in the consumer study. The statistical analysis for the sensory evaluation were performed by the program NCSS. One way analysis of variance (ANOVA) and General linear models (GLM) were performed with the significance level set at 95% ($p < 0.05$).

4 Results and discussion

4.1 Product evaluation

4.1.1 Product evaluation of fish cakes enriched with fish oil from experiment 1

Mixing of fish oil into the fish cakes had the greatest impact on the texture which became more fatty and wet with more fish oil mixed to the dough (Table 17, Appendix 5). Little difference was though in texture between the 6% and 8% group. Increased amount of the fish oil had also influence on the color, which seems to cause more yellow color of the fish cakes. The 6% group had fat odour and baking odour not detected in other groups. All the groups had dried fish and onion flavour.

4.1.2 Product evaluation of fish dishes with omega-3 oil from experiment 2

The results showed that to ensure better quality of the dishes the salt content and cooking time/frying of the patties and the fish cakes needs to be more carefully managed. For example, the arctic char fish cakes were unevenly fried and heterogeneous (Table 17, Appendix 5). For the haddock in curry-, garlic and lobster sauce the texture and appearance of the sauce needs to be more carefully managed because the sauce separated.

4.1.3 Product evaluation of the 12 prototypes from experiment 3

The product evaluations of the dishes from experiment 3 were conducted in three sections in May. Each section is represented separately.

Fish in white sauce and gratinated haddock with broccoli.

Mixing of omega-3 oil into these two dishes had impact on the flavour, odour and appearance for both the fish in white sauce and gratinated haddock with broccoli (Table 18, Appendix 6). Olive oil flavour and odour was observed in the enriched dishes but not in the conventional dishes and the enriched dishes had more oil on the surface and on the edges. Little difference were though in texture between the enriched dishes and the conventional dishes, the enrichment seems to cause more fatty texture for the gratinated haddock with broccoli but that was not mentioned for fish in white sauce.

Haddock in lobster sauce and haddock in curry sauce

Mixing of omega-3 oil into these two dishes had impact on the flavour, odour and texture for both Haddock in lobster sauce and haddock in curry sauce (Table 19, Appendix 6). Olive oil flavour and some foreign odour was observed in the enriched dishes that was not observed in the conventional dishes. For both the dishes the texture of the sauce was thicker for the conventional dishes than for the enriched dishes. Little difference was in appearance though the enrichment seems to cause different color for the enriched haddock in curry sauce but that was not mentioned for Haddock in lobster sauce.

Fish cakes and vegetable cakes

Mixing of omega-3 oil into fish cakes and vegetable cakes seemed to have little impact on the flavour, odour, appearance and texture. The difference between the enriched dishes and the conventional dishes for both fish cakes and vegetable cakes seemed to be that with addition of omega-3 oil the

odour and the flavour was more neutral as if more spices were in the conventional dishes as compared to the enriched dishes (Table 20 in appendix 6).

4.2 Sensory analysis

4.2.1 Sensory analysis of fish cakes enriched with fish oil from experiment 1

Almost no rancid odour or flavour was observed of the fish cakes (Table 7). A bit of dried fish flavour and umami was observed and a trace of salt and bitter flavour was of all of the samples groups. Almost no difference was observed between the cooled fish cakes and the frozen fish cakes and there was no significant difference between the two groups ($p > 0.05$). Also there was no difference between the sample groups i.e. the fish oil did not seem to have any significant affect.

Table 7 Results from sensory analysis of cooled fish cakes and frozen fish cakes. The p-value was observed with one way anova.

Samples:	Control	4% cod liver oil	6% cod liver oil	8% cod liver oil	p-value
Cooled fish cakes					
Rancid odour	2	3	3	4	0.789
Rancid flavour	2	4	6	4	0.766
Dried fish flavour	24	29	33	30	0.373
Salt	11	13	14	12	0.866
Umami	27	32	33	33	0.582
Bitter	14	10	12	10	0.639
Fatty mouth feel	25	28	30	32	0.711
Frozen fish cakes					
Rancid odour	8	5	6	7	0.945
Rancid flavour	7	9	8	10	0.871
Dried fish flavour	27	29	31	27	0.776
Salt	17	18	19	17	0.936
Umami	34	32	36	29	0.639
Bitter	14	14	15	14	0.957
Fatty mouth feel	27	28	30	30	0.933

4.2.2 Sensory analysis of the 12 prototypes from experiment 3

In Table 8, 9 and 10 the results of the sensory analysis of the prototypes from experiment 3 are shown. The odour and flavour scores evaluated were low for all samples, both in the beginning and after three and six months of storage. Except for olive oil odour and flavour also a bit of salt and pepper flavour was observed of all the samples. Other flavour and odour characteristic scores were below 10%, which represents the limit of detection of the attributes. Since the aim of the sensory analysis was to study shelf life and if the enrichement with omega-3 oil would affect the sensory attributes, low scores are considered good at least for the attributes representing shelf life. High scores for old storage odour and flavour is for example an indicator of storage of food. i.e. storage of fresh fish, cold storage odour and flavour can indicate decline in the shelf life of product. Like Magnusson et al., (2006) showed in their study of keeping quality of desalted cod fillets in consumer pack, that when these scores were above 20 on a scale from 0-100 most of the sensory panellists detected those negative attributes.

Olive oil odour and flavour were often significantly ($p < 0.05$) higher for the enriched dishes compared to the conventional dishes. Olive oil flavour is presented in figure 1. Reason for the olive oil odor and flavour is the omega-3 oil, it is a blend of fish oil and olive oil and it appears that the flavour and odour of the olive oil was easily detected in all the enriched dishes. Although the olive oil flavour and odour is often found significantly higher in the enriced dishes in the sensory evaluation it is not nescessearly something that affect consumer as shown later in the consumer study. Also it is not necessarly something that is bad in these kinds of dishes since olive oil is used in cooking and therefore not something completely foreing in ready to eat meals like these ones.

The olive oil flavour was highest at the end of the storage (after 6 months). It seems that the frozen storage increased the olive oil flavour and odoar but why is unclear and likely there are some cemical reactions either in the olive oil or interaction between compound in the dishes.The enriched dishes also always had higher scores compared to the conventional dishes except for gratinated haddock with broccoli and haddock in lobster sauce at month 0 but no likely explanation was found why.

No significant difference in other flavour and odour sensory attributes between the enriced and the conventional dishes is an indication of that the enrichement had no affect on sensory attributes tested.

The flavour and odor attributes give most information about decline in storage but texture like softness can be shelf life indicator for fish for examples that gets it gets drier during storage. But in this study the texture attributes were only information about the texture of the dishes. The texture attributes evaluated did not differ significantly ($p<0.05$) during storage. And small difference were in fatty mouth feel for enriched compared to conventional fish cakes and and haddock in lobster sauce. But other texture attributes did not differ between the enriched and the conventional dishes.

Table 8 Average sensory scores (GDA scale 0-100%) for the 12 prototypes in the beginning of the storage time. O3 is the enriched dishes. The p-value was observed with one way anova and GLM[†].

Samples:	Fish in white sauce			Gratinated haddock with broccoli			Haddock in curry sauce			Haddock in lobster sauce			Fish cakes			Vegetable cakes		
		O3	p-value[†]		O3	p-value		O3	p-value[†]		O3	p-value[†]		O3	p-value[†]		O3	p-value[†]
Odour																		
Olive oil odor	13	15	0,792	9	34	0,001*	7	8	0,684	13	7	0,137	8	21	0,098	16	18	0,733
Fish oil odor	5	5	0,935	5	7	0,367	1	2	0,685	5	2	0,169	4	4	0,060	4	7	0,340
Rancid odor	1	1	1,000	0	0	0,710	1	1	0,448	5	0	0,263	1	2	0,182	0	1	0,094
Cold storage odor	2	2	0,698	0	1	0,346	0	1	0,448	3	1	0,182	1	1	0,594	0	0	0,604
TMA	1	1	1,000	7	0	0,326	0	0	0,351	0	0	0,681	0	1	0,179			
Flavour																		
Salt	26	26	0,839	26	22	0,345	22	21	0,834	21	20	0,552	40	35	0,140	20	20	0,685
Pepper				29	20	0,231	20	19	0,857	17	22	0,053	46	39	0,164	30	25	0,212
Olive oil flavor	14	14	0,971	29	9	0,001*	8	13	0,354	17	6	0,049*	6	23	0,064	11	19	0,093
Fish oil flavor	5	5	0,707	4	4	0,803	3	5	0,147	7	3	0,081	3	4	0,233	2	5	0,040*
Rancid flavor	1	1	0,838	0	0	1,000	1	1	0,685	5	0	0,223	1	1	0,898	0	1	0,370
Cold storage flavor	2	1	0,960	0	0	0,699	3	4	0,773	9	7	0,112	1	1	0,551	0	0	1,000
TMA	1	1	0,602	7	0	0,558	0	1	0,359	2	0	0,266	0	0	0,594			
Texture																		
Softness	71	68	0,542	67	76	0,102	47	40	0,110	55	52	0,482	63	67	0,113	70	71	0,640
Juice	62	62	1,000	65	73	0,146	52	44	0,123	48	46	0,416	37	48	0,004*	58	58	0,917
Tenderness	73	67	0,288	71	76	0,349	59	51	0,123	59	56	0,266	59	64	0,051			
Rubber like	8	9	0,822	14	26	0,213	15	22	0,128	20	15	0,033*	19	15	0,190			
Fatty mouth feel	20	21	0,841	24	29	0,565	18	20	0,731	30	20	0,007*	27	31	0,140	28	32	0,128

* Significant difference between the omega-3 group and the control group.

Table 9 Average sensory scores (GDA scale 0-100%) for the 12 prototypes after 3 months of storage. O3 is the enriched dishes. The p-value was observed with one way anova and GLM[†].

Samples:	Fish in white sauce			Gratinated haddock with			Haddock in curry sauce			Haddock in lobster sauce			Fish cakes			Vegetable cakes		
		O3	p-value		O3	p-value		O3	p-value		O3	p-value		O3	p-value[†]		O3	p-value[†]
Odour																		
Olive oil odor	17	19	0,648	10	26	0,005*	9	20	0,027*	14	16	0,698	8	14	0,060	10	13	0,265
Fish oil odor	5	5	0,970	4	5	0,819	4	5	0,652	5	5	0,854	5	8	0,418	5	3	0,407
Rancid odor	2	1	0,590	1	2	0,401	1	1	0,880	1	1	1,000	0	2	0,102	2	1	0,380
Cold storage odor	3	2	0,488	1	1	0,567	4	2	0,449	3	2	0,679	2	1	0,170	2	2	0,685
TMA	1	1	0,897	1	1	0,636	1	0	0,506	1	1	0,497	0	1	0,133			
Flavour																		
Salt	18	20	0,603	21	22	0,689	20	20	0,962	18	21	0,358	27	27	0,957	22	23	0,823
Pepper	21	21	0,934	24	27	0,640	24	20	0,288	19	16	0,222	36	33	0,413	29	24	0,071
Olive oil flavor	19	20	0,964	7	30	0,000*	7	26	0,000*	13	18	0,169	8	19	0,014*	13	20	0,121
Fish oil flavor	6	5	0,833	2	5	0,062	6	5	0,759	5	5	0,928	4	5	0,465	4	4	0,814
Rancid flavor	2	2	0,862	1	1	0,443	2	6	0,131	2	3	0,570	1	3	0,390	1	1	0,351
Cold storage flavor	4	4	0,905	3	4	0,599	9	15	0,272	9	11	0,578	2	1	0,476	3	3	0,155
TMA	1	1	0,802	1	1	0,455	1	1	0,780	1	1	0,928	0	1	0,470			
Texture																		
Softness	72	72	0,905	70	71	0,711	57	52	0,439	51	57	0,263	54	55	0,620	70	67	0,136
Juice	70	68	0,702	66	68	0,578	52	45	0,279	48	54	0,263	43	53	0,011*	63	62	0,620
Tenderness	71	72	0,955	69	73	0,418	53	49	0,542	54	54	0,940	59	62	0,284			
Rubber like	6	6	0,981	5	7	0,440	10	13	0,459	13	13	0,967	12	13	0,888			
Fatty mouth feel	23	23	0,990	18	24	0,124	20	22	0,620	13	11	0,565	18	25	0,044*	27	28	0,390

* Significant difference between the omega-3 group and the control group.

Table 10 Average sensory scores (GDA scale 0-100%) for the 12 prototypes after 6 months of storage. O3 is the enriched dishes.The p-value was observed with one way anova and GLM[†].

Samples:	Fish in white sauce			Gratinated haddock with			Haddock in curry sauce			Haddock in lobster sauce			Fish cakes			Vegetable cakes		
		O3	p-value		O3	p-value		O3	p-value[†]		O3	p-value		O3	p-value[†]		O3	p-value
Odour																		
Olive oil odor	8	26	0,001*	9	23	0,020*	9	19	0,110	8	19	0,047*	5	18	0,106	6	24	0,001*
Fish oil odor	5	6	0,670	5	6	0,734	4	4	0,390	5	5	0,915	5	6	0,598	4	6	0,462
Rancid odor	1	1	0,535	1	1	0,644	0	1	0,250	1	1	1,000	1	1	0,451	2	3	0,729
Cold storage odor	1	2	0,373	1	1	0,625	1	3	0,356	3	5	0,500	2	2	0,050*	1	1	0,855
TMA	1	1	0,543	1	1	0,855	0	1	0,563	1	1	0,853	1	1	0,626			
Flavour																		
Salt	16	25	0,086	19	24	0,340	17	20	0,246	22	22	0,808	25	27	0,529	18	18	0,870
Pepper				20	22	0,652	18	22	0,287	20	21	0,764	33	42	0,002*	23	29	0,310
Olive oil flavor	13	29	0,013*	8	30	0,000*	9	22	0,092	9	23	0,014*	5	22	0,012*	6	29	0,001*
Fish oil flavor	5	9	0,132	5	7	0,348	4	4	0,416	5	7	0,625	5	7	0,429	4	8	0,193
Rancid flavor	1	2	0,321	1	3	0,264	1	2	0,287	1	6	0,177	1	2	0,281	2	4	0,451
Cold storage flavor	3	3	0,692	1	2	0,637	14	14	0,732	10	13	0,636	8	9	0,388	1	2	0,616
TMA	1	1	0,598	1	1	0,320	1	1	0,422	1	3	0,121	1	1	0,732			
Texture																		
Softness	67	69	0,826	62	63	0,808	43	43	0,977	37	42	0,371	64	64	0,965	67	68	0,869
Juice	62	68	0,370	61	62	0,881	41	42	0,828	32	42	0,218	50	55	0,173	65	65	0,987
Tenderness	72	75	0,698	71	72	0,878	53	54	0,879	49	57	0,290	65	65	1,000			
Rubber like	4	6	0,529	5	5	1,000	10	11	0,636	13	19	0,225	8	8	1,000			
Fatty mouth feel	21	28	0,184	10	20	0,054	16	17	0,771	14	18	0,449	17	23	0,009*	23	30	0,253

* Significant difference between the omega-3 group and the control group.

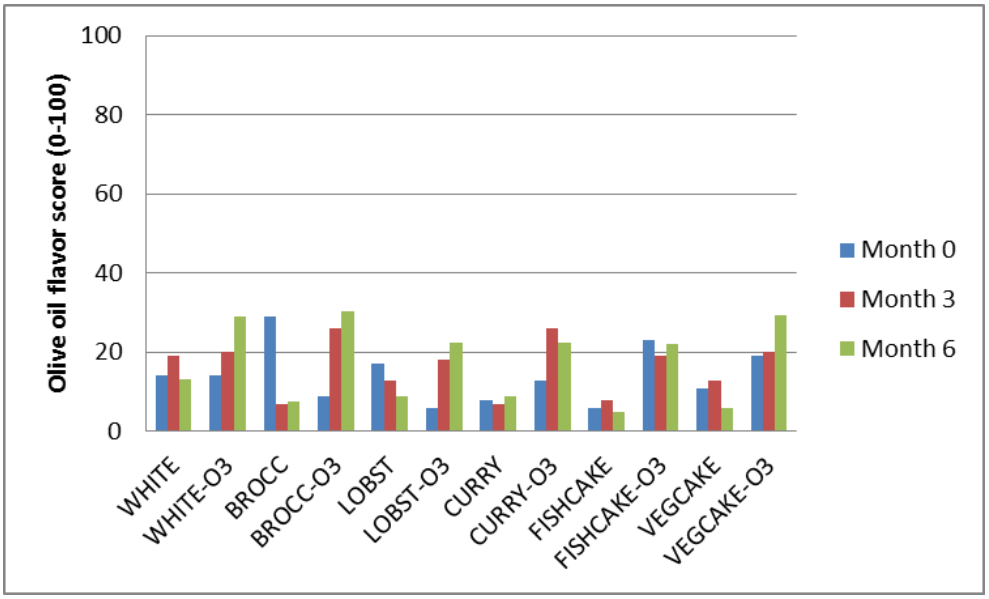

Figure 2 Scores of olive oil flavour from sensory analysis of the 12 prototypes in experiment 3. –O3 indicates the enriched dishes.

The results from the product- and sensory evaluation in experiment 1-3 showed that neither fish oil nor rancid flavour and odour were prominent in the enriched products. According to an overviews written by Jacobsen, (2008) and Kolanowski et al. (2006), fish oil flavour and odour are the sensory attributes that often negatively impact the sensory properties of omega-3 enriched foods but Kolanowski et al.

(2006) also pointed out there are only few studies available of sensory evaluation on food enriched with fish oil. Therefore more studies are needed.

The results from experiment 1 showed that up to 8% of cod liver oil could be used for the enrichment of fish cakes without affecting the odour or flavour. Other studies have also shown that addition of up to 60g kg^{-1} of fish oil is possible but depend on food enriced (Kolanowski et al., 2006). The addition of fish oil in the fish cakes increased the fatty mouth feel and affected the color. These attributes could be adjusted by e.g. changing the amount of other fat ingredients in the recipe, optimize the production method and add color ingredients if needed. To prevent the fatty mouth feel it would also be possible to try mixing of the oil earlier in the production process of the fish cakes. Based on acceptable results from experiment 1 other types of dishes were tested with 6% omega-3 oil which is approximately the needed amount to fulfill the recommended daily dosage of omega-3. The addition of the omega-3 oil into the dishes had minor effects on sensory characteristics of the products, concluding that the tested amount of the oil could be used for enrichment.

Six different dishes with and without the omega-3 oil were evaluated in experiment 3 with product- and sensory evaluation. The enrichment affected the sensory attributes of some of the products as olive oil flavour and odour were noticed in fish dishes with sauce, especially enriched gratinated haddock with broccoli. Gratinated haddock with broccoli has as the name indicate broccoli in the recepie and also asparagus, maybe this green vegetable had some influence on the olive oil flavour. If not that there was propably something else in that recipe not found in the other dishes influencing the olive oil flavour and odour but no likely explanation is there. The dishes with sauce also had a more fatty texture probably do to the oil enrichement.

After six months of storage cold storage odour and flavour was barely detected but was slightly increased in the haddock in curry- and lobster sauce. Rancid odour and flavour, which is a critical factor in shelf life of products containing omega-3 fatty acids as mentioned earlier, was hardly detected. Fish oil odour and flavour were also low. These results indicate that the products have a shelf life of at least 6 months and addition of omega-3 oil is a realistic option without significant deterioration of its sensory quality, this is accordance with what Jacobsen, (2008) found out for addition of omega-3 into food emulsions.

This experiment is the first that have ever used this omega-3 oil for enrichement and therefore comparisons to other studies with this omega-3 oil are impossible. But others for example Kolanowski et al. (2004) studies the stability, sensory quality, texture properties and nutritional value of fish oil enriched spreadable fat found that there was no significant difference or little in overall sensory quality between the enriched spreadable fat and control spreadable fat during storage of three months, this is consistent with the results of this reaserach. Again indicating that enrichement of various foods with omega-3 is a realistic option.

4.3 Chemical analysis

The water, protein, fat, ash and salt content of all the 12 prototypes is shown in Table 11. The main difference between conventional dishes and enriched dish was as expected higher fat content for the enriched dishes compared to the conventional dishes with the exception of gratinated haddock with

broccoli. Recipes were adjusted by the seafood producer before production, fat absorption during frying of vegetable cakes could explain the high fat content of the cakes.

Table 11 Results from chemical analysis of the 12 prototypes.

Sample	Water (%)	Protein (%)	Fat (%)	Ash (%)	Salt (NaCl)(%)
Fish in white sauce	74.6	6.5	6.2	1.5	1.0
Fish in white sauce O3	72.8	6.2	10.2	1.4	0.9
Gratinated haddock with broccoli	76.1	5.9	5.3	1.7	1.2
Gratinated haddock with broccoli O3	77.7	6.3	4.3	1.7	1.1
Haddock in lobster sauce	75.7	10.7	5.3	1.3	0.8
Haddock in lobster sauce O3	72.9	10.9	9.2	1.4	0.8
Haddock in curry sauce	72.4	11.7	7.3	1.5	0.8
Haddock in curry sauce O3	70.5	9.9	11.1	1.5	1.0
Fish cakes	67.1	10.9	4.8	2.2	1.5
Fish cakes O3	63.7	9.7	11	2.0	1.4
Vegetable cakes	61.7	3.5	8.5	2.1	1.3
Vegetable cakes O3	60.8	3.3	9.2	2.1	1.3

4.3.1 Fatty acid composition

The fatty acid profile of the 12 prototypes is illustrated in figure 6 in appendix 7 and the main results are illustrated in figure 3. The enriched dishes have as expected higher levels of EPA+DHA and total omega-3 than the conventional dishes. Although the same amount of the omega-3 oil was added to all the enriched dishes considerable difference between dishes was observed but other ingredients in the recipes, other than the omega-3 oil have influence on the fatty acid composition of the dishes and variance in ingredients.

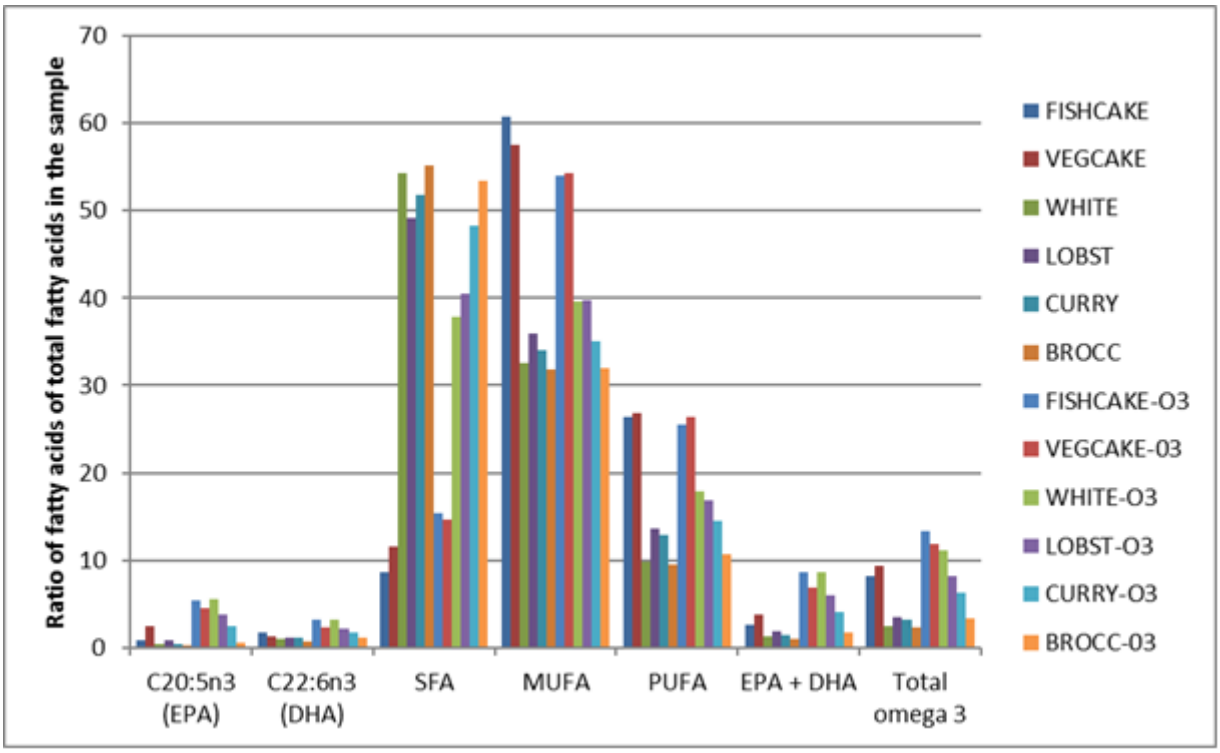

Figure 3 Profile of the EPA, DHA, SFA, MUFA, PUFA, EPA+DHA and Total omega-3 for the 12 prototypes from experiment 3.

4.3.2 Peroxide value (PV)

The peroxide value increased for all the samples after storage for three months (Figure 4 and table 21 in appendix 8). After storage for six months the value decreased again or was similar except for fish cakes (conventional) and vegetable cakes (conventional and enriched). Possible reason for the decrease in value aftur 6 months this is that the lipid hydroperoxides come from fish products are unstable, they have probably been transformed into the secondary oxidation prouduct after storage (Frankel, 2005). Overall the value was higher for the enriched dishes compared to the conventional dishes indicating more oxidation. In the beginning and after six months the PV for vegetable cakes (conventional and enriched) was highest, which might be explained by the frying of the cakes. During frying, the temperature becomes higher and it is possible that it has increased the oxidation rate like Jacobsen pointed out in her review of omega-3 enriched food that high temperature increase oxidation (Jacobsen, 2008).

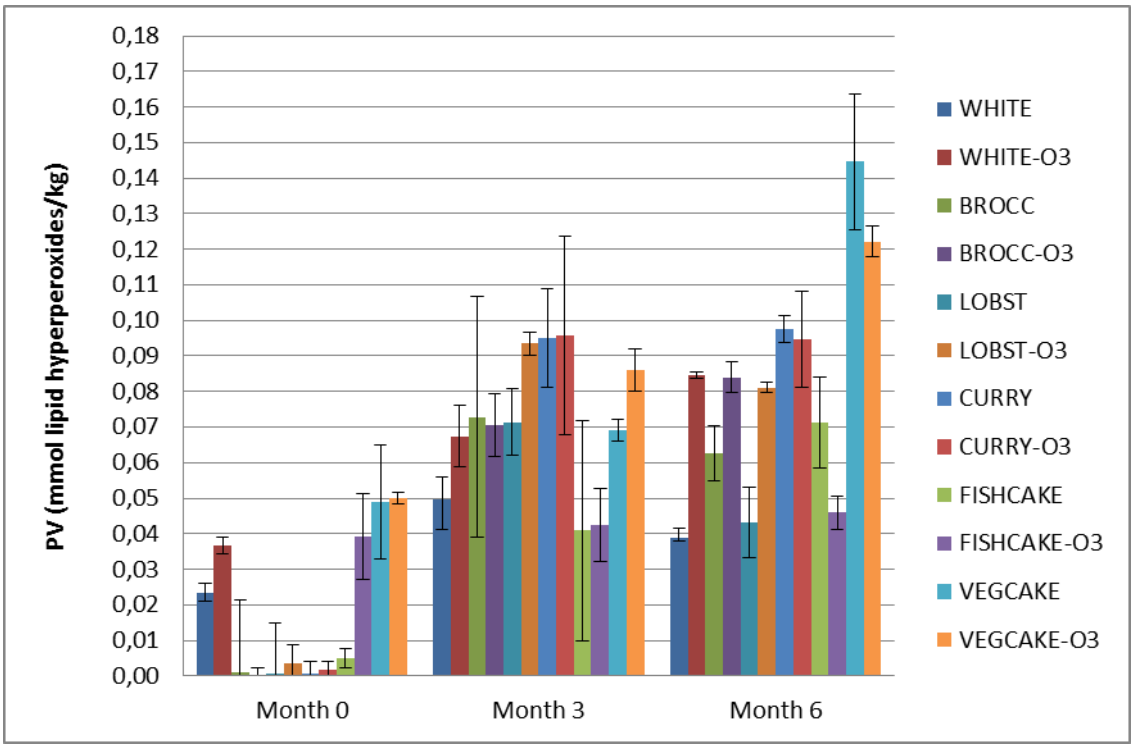

Figure 4 Hydroperoxide values with standard deviation of the 12 prototypes from experiment 3 (see sample code in table 3) during storage for 6 months.

4.3.3 Thiobarbituric acid reactive substances (TBARS)

The TBARS value increased for all the samples after three months of storage except for conventional and enriched fish and vegetable cakes. After six months of storage the values increased for the conventional and enriched vegetable cakes (Figure 5 and table 22 in appendix 8). The TBARS values were considerably higher for the fish cakes and vegetable cakes, especially the vegetable cakes (both conventional and enriched).

Likely explanation is the clorofil found in vegetables that convert triplet oxygen to sinlet oxygen and induce oxidation. These groups were also fried like I mentioned for the PV results and that could also partially explain the higher TBARS values. Both for the PV and TBARS it important to keep in mind that results can be different, both because of how the measurement is performd and also because of the method used (Frankel, 2005) and therefore it is also difficult to compare results from these measurements with other results for similar food. But a similar study by Dellarosa et. al (2014) on PV and TBARS of enriched fish cakes with fish oil showed higher values after 28 days of refrigerate storage (Dellarose, et al, 2014 – Submitted paper). Possible reason for this difference other than variance in the measurements are foraxample like Jacobsen (2010) pointed out in her study of omega-3 enriched foods that oxidative stability depends largely on the quality of the fish oil used. The difference between these finding can therefore be the initial quality of the fish oil or omega-3 oil used for enrichement.

The results from the PV and TBARS measurements are not reflected in the sensory results as the trained sensory panel did not detect rancidity characteristics. Thes values are not high enough to be detected in these products in sensory evaluation.

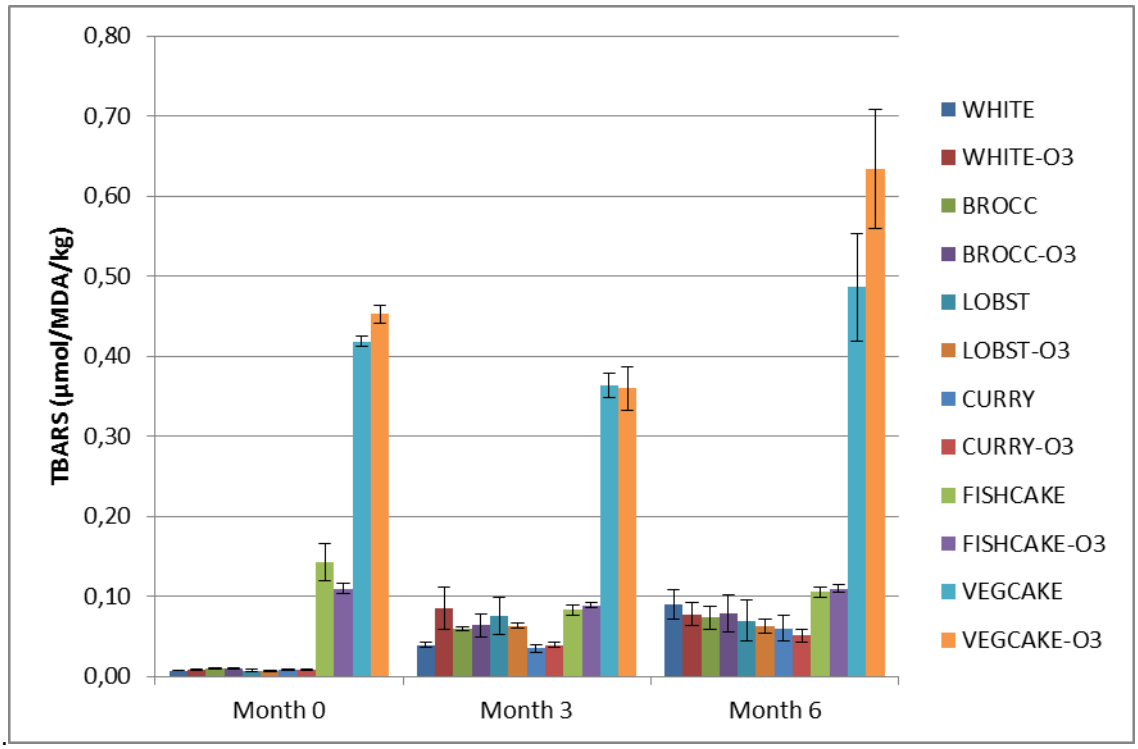

Figure 5 TBARS value with standard deviation of the 12 prototypes from experiment 3 (see sample code in table 3) during storage for 6 months.

4.4 Consumer study

Altogether 27 participants completed the study in group one (10 men and 17 women) and 50 in group two (15 men and 35 women). The average age of the participants in the consumer study was 57 years for the control group and 56 years in the omega-3 group. Total dropout rate was 29% for the omega-3 group and 18% for the control group. The dropout rate is higher in the omega-3 group but since there were no records of reasons of dropouts it is hard to predict if the meals were the reason for more dropout in the omega-3 group compared to the control group.

4.4.1 Purchase habit and consumption of fish and supplements

Table 12 shows results from the first questionnaire. The participants purchased fish or other fish products around 1.2 time per week and ready to eat fish dishes 0.3 times per week. Consumption of fish as the main dish was around 1.4 times per week in the control group, but 1.7 times a week in the omega-3 group, with no significant difference ($p < 0.05$). Ready to eat fish meals were less frequently consumed, or 0.3 times per week. This does not fulfil the recommendation of consumption of fish 2 times per week or more often (NNR, 2012) and like pointed out in the report from the dietary survey of Icelanders in 2011 people in the age group 18-30 years old consume half of what people in the age group 61-80 years old (Þorgeirsdottir et al., 2011). Participants took supplements like vitamins, minerals or cod liver oil on average 4.6 times per week in the control group and 4.9 times per week in the omega-3 group. Both groups claimed most often that they used information on food packaging. That gives us an idea of the attitude and behavoir of the participants. Earlier concept testing in the

Nordic project Conveneince enriched seafood products showed that people putting emphasis on their health looked at information on food packaging more than those who not placed emphasis on their food healthiness.

Table 12 Description of participants characteristics. Control group (consumed conventional meals) and omega-3 group (consumed meals enriched with omega-3). Values are averages with standard deviation (SD).

	Control group (N=50)	Omega-3 group (N=27)
Gender and age		
Men (N)	10	15
Women (N)	17	35
Age	57.2 (6.3)	55.8 (5.1)
Purchase of fish products per week		
I buy fish or other fish products	1.2 (0.9)	1.2 (0.9)
I buy ready to eat fish dishes	0.3 (0.4)	0.2 (0.4)
Consumption of fish products per week		
Fish as main dish	1.4 (0.9)	1.7 (1.0)
Ready to eat fish dishes	0.3(0.5)	0.3 (0.4)
Intake of supplements		
How often do you take supplements etc. vitamins, minerals or cod liver oil	4.6 (2.6)	4.9 (2.6)
Information on packaging		
Do you look at information like ingredients on food packaging?	Never = 4% Seldom = 8% Occasionally = 23% Often = 42% Always = 23%	Never = 0% Seldom = 13% Occasionally = 29% Often = 38% Always = 19%

4.4.2 Liking of the meals

Average score of liking was highest for conventional fish in white sauce (Av., 7.9) (table 13). The conventional dishes had generally higher liking than the enriched dishes except for haddock in curry sauce and haddock in lobster sauce. Suggested explanation is the texture of the sauce. But in the conventional dishes the sauce was too thick and after enrichement with the oil the texture of the sauce was better. In week one there were no significant differences in liking scores between the enriched and the conventional dishes except for haddock in lobster sauce, the enriched haddock in lobser sauce had significantly higher liking ($p< 0.05$). In week four the enriched fish in white sauce and gratinated haddock with broccoli were signifivantly less liked than the conventional dishes. Repeated consumption did not have an effect on liking of the dishes with the exception of the enriched haddock

in lobster sauce which was significantly less liked in week four (p=0.007). These results are in inconsistent with other similar stuies on liking of dishes after repeated in home consumption which found that repeted consumption results in decrease in liking (Zandstra, De Graaf, Mela, et al., 2000; Zandstra, de Graaf, & van Trijp, 2000; Zandstra et al., 2004).

Table 13 Liking (9-point hedonic scale) of meals in week one and four, both the enriched (omega-3 group) and the conventional dishes (control group).

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average	(Sd)	N	Average	(Sd)	N	Average	(Sd)	N	Average	(Sd)
Fish in white sauce	27	7.3	(1.8)	51	7.9	(1.2)	25	6.8[a]	(2)	46	7.8[a]	(1.4)
Gratinated haddock with broccoli	27	7.0	(1.6)	51	7.7	(1.6)	25	6.7[a]	(1.6)	48	7.7[a]	(1.4)
Haddock in curry sauce	27	7.2	(1.3)	51	6.7	(2.2)	26	6.6.	(1.8)	46	6.2	(2.3)
Haddock in lobster sauce	27	7.6[a,b]	(1.3)	50	6.7[a]	(2)	25	6.1	(2.3)	45	5.9	(2.4)
Fish cakes	27	6.9	(2)	50	7.3	(1.8)	26	7.1	(2.1)	49	7.2	(1.7)
Vegetable cakes	27	7.2	(1.7)	52	7.8	(1.8)	26	6.7	(2.1)	47	7.1	(2.2)

[a] Significant difference between the omega-3 group and the control group.
[b] Significant difference between week 1 and week 4.

Subsequently participants were given opportunity to give comment on if there was anything they liked or disliked regarding the dish they were consuming. In appendix 9 and 10 the comments are shown along with detailed results for each meal. The comments were mainly about the sauce for those dishes that had sauce. It was not mandatory for the participants to answer the question and only few of them gave comments.

4.4.3 Ranking of all the dishes

In the end of the week the participants ranked the dishes from one to six (dish number one = the dish most liked and number six = least liked. In week one the average score was lowest for the haddock in curry sauce in the omega-3 group indicating that the omega-3 enriched haddock in curry sauce was the most liked dish in week one (table 14). The enriched vegetable cakes received the highest scores, indicating that this dish was the least liked in week one. In the control group the fish in white sauce and vegetable cakes were the most liked dishes and haddock in lobster sauce the most disliked in week one. In week four, the conventional fish in white sauce was the most liked but haddock in lobster sauce the least liked. In the omega-3 group fish in white sauce was the most liked, but the omega-3 enriched haddock in lobster sauce the least liked. The results indicated that the fish in white sauce was generally the most liked dish, but the haddock in lobster sauce the least liked. This is in harmony with the results of the results of the liking of the dishes.

Table 14 Ranking of the dishes in week one and four for both the omega-3 group and the control group

	Week 1		Week 4	
	Omega-3 group	**Control group**	**Omega-3 group**	**Control group**
Fish in white sauce	2-3	1-2	1	1
Gratinated haddock with broccoli	5	3	5	2
Haddock in curry sauce	1	5	4	5
Haddock in lobster sauce	2-3	6	6	6
Fish cakes	4	4	2-3	4
Vegetable cakes	6	1-2	2-3	3

4.4.4 Questions participants answered prior to consumption

The questions participants answered prior to consumption of the meals were feeling of hunger, desire to consume the dishes and how interesting the participants considered the taste are represented in table 29 - 31 in appendix 11.

The scores for the feeling of hunger ranged between 5.0 and 5.6 on a seven-point scale indicating that the participants were rather hungry prior to consumption of the dishes. In week one the average scores for feeling of hunger were similar for all the dishes within each group but difference was between the omega-3 group and the control group with significantly ($p< 0.05$) more feelling of hunger the in the omega-3 group for the gratinated haddock with broccoli, haddock in curry sauce and fish cakes. The control group was not as hungry. In week four, the scores for the feeling of hunger were similar within each group but for haddock in lobster sauce the feeling of hunger was significantly lower in the control group compared to the omega-3 group. Significant differences were observed between week one and four in the control group for fish in white sauce, gratinated haddock with broccoli and haddock in curry sauce where participants felt hungrier in week four. No apparent explanation is for this difference both between groups and dishes.

The scores for desire to consume the dishes ranged from 4.5 to 5.8 indicating that the participants had desire to eat the dishes. In week one the average score of desire to eat the dish were similar for all the dishes and almost no difference was between the omega-3 group and the control group. In week four, the scores were similar between groups but a little lower scores compared to week one with significantly ($p< 0.05$) lower desire to consume haddock in lobster sauce in both groups compared to week one. Zandstra et al., (2000) also found that a decrease in desire to eat after repeated consumption for 10 weeks. Decrease in desire to consume is propbly normal after so intensive consumption of the same meals for four week although there could been have other factors having effect, since the decrese in liking was minor.

The scores for how interesting the participants considered the taste to be ranged from 4.5-5.9 this indicated they thought the taste was interesting. In week one the average score of how interesting they

thought the taste of the meal were rather similar for all the dishes and no differences between the omega-3 group and the control group. In week four, the scores were a little lower for haddock in curry and lobster sauce in both groups. After repeated consumption they were familiar with the taste and likely explanation for decrease in week four for haddock in curry and lobster sacue is because of overall liking of this dishes but that in consistent with the decrase of liking of these dishes.

If looking at the results from all of these three questions together it can be concluded that the participants were hungry, desired to consume the dishes and they thought the taste were interesting. Little difference was between groups and dishes and repeated consumption did have a little effect except for haddock in lobster sauce.

4.4.5 Questions about the dishes

The main results of liking of appearance, taste and texture of the dishes in week one and four for both the omega-3 group and the control group showed that participants liked these attributes well. The average score for appearance were between 4.3 and 6.1, between 4.4.and 6.2 for taste and 4.2 and 6 for texture on a seven-point scale (Table 32 in appendix 12). The results of liking of these attributes are in consistent with the overall liking of the dishes and other questions but comparison to other similar results were not applicable since no published data were found for liking of these attributes of omega-3 enriched dishes. Usually the participants are only asked about general liking, but Zandstra et al., (2000) asked about perceived flavour intsensity and perceived sweetness but no results were shown.

Liking of appearance of the haddock in curry and lobster sauce was significantly higher in the omega-3 group in week one compared to the control group and also after repeated consumption but not with significant difference. Likely explanation is again the thickness of the sauce for theses two dishes in the control group. Liking of the appearance of the omega-3 enriched haddock in lobster sauce was significantly decreased in week four but still higher liking than for the conventional dish.

Liking of the taste of the fish in white sauce was significantly ($p< 0.05$) higher in the control group than the omega-3 group, both in week one and four apparent explanation are not known why this difference is significant the omega-3 oil could be the reason. The same trend was seen for gratinated haddock with broccoli in week four and again no apparent explanations are known. The omega-3 enriched haddock in curry sauce was significantly more liked with regard to taste in week one as compared to the conventional dish. The liking of the taste was though significantly decreased in week four for the haddock in curry sauce. These results are in consistent with other results in this study. The liking of the taste of the omega-3 enriched haddock in lobster sauce was lower in week four as compared to week one. Liking of conventional vegetable cakes was higher in week one as compared to week four.

Liking of the texture of the conventional fish in white sauce was higher in both week one and four as compared to the enriched dish likely explanation is that the omega-3 oil had some influcne on the texture since that is the only variable different between theh dishes. The opposed was seen for haddock in lobster sauce in week one. The liking of the texture was significantly reduced in week four for the enriched haddock in lobster sauce.

4.4.6 Questions participants answered post consumption

The scores for how much the participants consumed of the meals indicated that most participants finished or nearly finished their meals (Table 15). Both in week one and week four and for both the omega-3 group and the control group the scores were similar except for omega-3 enriched haddock in lobster sauce, where less was consumed in week four. Participants were asked to eat as much of the meals as they could and preferably finish it. These results show that they followed the instructions given.

Participants were also asked if they desired to consume more of the dish (Table 33, Appendix 13). The average scores of desire to eat more of the dishes was higher in the control group for all the dishes compared to the omega-3 group and with significant difference for fish in white sauce and vegetable cakes in week one and for fish in white sauce, gratinated haddock with broccoli and fish cakes in week four. Apparent explanation could be that the participants in the omega-3 group felt more satety since the both groups were consumping equal amount of the dishes but we have not data to support that. The average scores were similar between weeks one and four. Zandstra et al., (2004) asked this same question for regular consumption of chicken soups and they also found small decries in desire after repeated consumption for 3 weeks.

Participants were also asked about boredome of consumption of the dishes. The scores ranged from 4.1 to 6.0 indicating that the participants got somewhat bored with some of the dishes and very bored with other dishes (Table 34, appendix 13) this is in consistent with earlier study which found that repetitive eating results in increase in boredome (Zandstra et al., 2000). In week one the average scores of boredom of consumption of the dishes was higher for the omega-3 group for haddock in curry- and lobster sauce. Again these two dishes are different compared to the other dishes. No likely apparent reason why they got more bored with these dishes is know. This is also somehow in inconsistent with other question were usually these dishes were more liked in the omega-3 group. In week four similar differences were observed. There were some differences between the average scores for the dishes in week one and four with significant difference for the haddock in curry- and lobster sauce in the omega-3 group.

In the questionnaire were also detailed questions about state of feeling of satuation, general feeling and more after consumption of the dishes but results will not be shown or discussed at this time because the outecome was that participante were neutral towards all these factors and no difference was between the groups nor weeks.

Table 15 How much was consumed of the dish for all the dishes in week one and four for both the omega-3 group and the control group. "How much of the dish did you eat (about)?" Scale (1-5): 1= Nothing, 5 = The whole meal.

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average	(Sd)	N	Average	(Sd)	N	Average	(Sd)	N	Average	(Sd)
Fish in white sauce	27	4.9	(0.4)	51	4.9	(0.2)	25	4.8	(0.7)	45	4.8	(0.5)
Gratinated haddock with broccoli	27	4.9	(0.4)	51	4.9	(0.3)	25	4.8	(0.4)	48	4.8	(0.6)
Haddock in curry sauce	27	4.8	(0.5)	52	4.5	(0.8)	26	4.5	(0.9)	48	4.4	(1)
Haddock in lobster sauce	27	4.7[b]	(0.4)	51	4.6	(0.8)	25	4.2[b]	(1.1)	45	4.4	(0.9)
Fish cakes	27	4.5	(0.8)	51	4.8	(0.5)	26	4.3	(1)	49	4.7	(0.6)
Vegetable cakes	26	4.8	(0.6)	52	4.9	(0.6)	26	4.7	(0.6)	47	4.6	(0.7)

[a] Significant difference between the omega-3 group and the control group.
[b] Significant difference between week 1 and week 4.

4.4.7 Questions about the meals preparation

The dishes were most often consumed during lunch time or dinner, more commonly as dinner. This was similar between weeks. For fish in white sauce the most common cooking methods were heating in oven or microwave oven and serving with rye bread. The fish cakes were most often heated in the oven or on a pan, and served with potatoes and salat. Heating in oven were most common for the haddock in curry sauce and haddock in lobster sauce, the most common side dishes were salad and vegetables. The gratinated haddock with broccoli was most often heated in the oven or in the microwave oven commonly served with bread. For vegetable cakes the most common cooking method was heating in oven or microwave oven, served with the yoghurt sauce and date chutney that were a part of the meal the particpants received with the vegetable cakes. One of the advantages of home use test like this one is that the product is undir normal conditions, both the preparation and the consumption (Meilgaard et al., 2006). We also asked about the meals preparation, if it were simple to cook or heat the dishes, if it was quick and convenient. In both groups they found the preparation generally simple, quick and convenient. The scores ranged between 5.8 and 6.9, 5.7 and 6.9 and 5.7 and 6.9 respectively on a 7-point scale (Table 35, Appendix 14).

4.4.8 Questions about desire to consume the dishes again after 3 days, 1 week, 2 weeks and one month

The interest to consume the dishes again after 3 days was generally low, both in the enriched and control groups in week one, and the scores were considerably lower in week four, especially for the enriched haddock in lobster sauce dish (Table 36, Appendix 15). The desire to consume the dishes was higher after longer time had past. The interest to consume the dishes again after one week was slightly higher as compared to three days. The interest to consume the dishes again after two weeks was higher than after one week. And finally the interest to consume the dishes again after one month was more than the estimate of interest after two weeks. The scores ranged from 4.9 to 5.1 in the

omega-3 group and 4.3 to 5.7 in the control group in week one, but 4.7 to 4.9 in the omega-3 group and 4.2 to 5.6 in the control group in week four, indicating quite high interest, but different by dishes though no significant differences were observed. These findings are conteracts with previously published work of Zandstra et al., (2004) and Moskowitz et al., (2000) showing different in interest after extended time.

4.4.9 Buying intention

The scores for intention to purchase the products varied rather much, or from 3.5 to 5.4 on a seven-point scale from one; very unlikely to seven; very likely (Table 37, Appendix 16). The scores were higher in the control group for all the dishes except for the Haddock in curry- and lobster sauce, both in week one and week four. The averages scores of probability of purchasing these dishes was a little lower in week four compared to week one.

4.4.10 Additional remarks

At the end of the consumer study participants were asked if they had any additional remarks like if there were something that happened that led to that they couldn't follow the plan. Almost all the participant could follow the plan as planned in both groups and in both weeks. Of those who answered were 21% of the participants in the omega-3 group in week one and 18% in the control group that could not follow the plan throughout the week. In week four 29% of the participants in the omega-3 group and 20% in the control group could not follow the plan. The most common reason for not sticking to plan was some incident leading to they had to consume two dishes in one day instead of eating one dish a day for six days, so that they consumed the six dishes in five days. Most of the comments from the participants were thanks for the opportunity to participate in the research and comments of overall satisfaction with the meals.

Participants were hungry, desired to consume the dishes and they thought the taste were interesting. Little difference was between groups and dishes and repeated consumption did have a little effect except for haddock in lobster sauce. Participants in both groups also found the preparation generally simple, quick and convenient. Overall the liking of appearance, taste and texture were higher for the conventional dishes exept for haddock in curry sauce and haddock in lobster sauce. Repeated consumption did have some effect depending on dishes. The scores for how much the participants consumed of the meals indicated that most participants finished or nearly finished their meals. The scores for desire to consume more of the dishes indicated that the participants had little desire to eat more of the dishes right after consumption. And they got somewhat bored with some of the dishes and very bored with other. The desire to consume the dishes was higher after longer time had past and after one month they desired to consume the dishes again. The likelihood of buying the product varied and was a little lower after the four weeks compared to week one

According to the results of the consumer study the general liking of the dishes were good in both groups and participants were positive towards consumption, preparation and sensory attributes of the dishes and desired to consume the dishes again after certain period of time and would buy them again after extended period of time. Overall the enriched haddock in curry sauce and haddock in lobster

sauce had different scoreas compared to the conventional dishes. Likely explanation of this difference as mentioned earlier is the thickness of the sauce, the enrichement into these dishes had good influence on the liking and other attributes but enrichement in the other dishes was more towards negative effects but not negative as if we look at the scales the scores were usually rather high.

Next step in data analysis would to be to conduct correlation tests for the questions for more detailed results and further conclusion of the consumer study.

5 Conclusion

The results from the product- and sensory evaluation in experiment 1-3 did not show any distinctive feature of fish oil or rancid flavour and odour. However, texture and appearance were affected by the omega-3 enrichement, which should be dealt with in further optimizing during the processing of the products. However, these attributes not necessarily negatively affect consumers. In experiment 3 olive oil flavour and odour was detected in some enriched dishes especially the enriched gratinated haddock with broccoli after extended storage. The omega-3 oil was a blend of fish oil and olive oil which can explain the olive oil flavour and odour. The olive oil odour and flavour was only detected in some products which could be explained by other ingredients in the dishes. The dishes had not reached end of shelf life after storage in -18°C after six months. Sensory attributes representing decline in shelf life, such as cold storage odour and flavor and rancid odour and flavour were hardly detected, but rancidity is a critical factor in shelf life of products with sensitive omega-3 fatty acids. As the enriched dishes had higher fat content compared to the conventional dishes they showed higher oxidation in the PV and TBARS measurements. This needs to be taken into consideration before production of the dishes for the market due to risk of oxidation over longer period of time.

The conventional dishes had generally higher liking than the enriched dishes, except for omega-3 enriched haddock in curry sauce and omega-3 enriched haddock in lobster sauce. This was also true for liking of appearance, taste and texture. Repeated consumption of the dishes six times a week over period of four weeks did not have an effect on liking of the dishes with the exception of the enriched haddock in lobster sauce which was significantly less liked in week four compared to week one. On average the participants liked most the fish in white sauce but disliked the haddock in lobster sauce most. The low drop-out rate of the participants in the fourth week of the consumer study indicates a general liking despite such an intense study. Participants were positive towards consumption, preparation and sensory attributes of the dishes and desired to consume the dishes again after certain period of time and would buy them again after extended period of time.

A possible motive for participating the whole period could be because of the health benefits involved. It is important to take into account that the results in this study only apply to the age group of 50 years and older.

From the results of this study it can be concluded that enrichment of ready to eat meals with omega-3 fatty acids is a realistic option, but the flavour of different dishes is differently affected by the oil and some recepies appear to more suitable than other. The next gate in the product development process would be optimization of the recipies where these results would to be taken into consideration during further product development of convenience products enriched with omega-3 oil.

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Appendix

Appendix 1

Fiskibollur

Innihaldslýsing: Ýsa 75% , laukur, *hveiti,* trefjar, kartöflusterkja, *egg,* krydd (salt, pipar, laktósa, sellerý, kurkuma,

grænmetisprótein, ger,grænmetisfita (sólblóma og pálma) hvítlaukur, kekkjavarnarefni E551)

Lýsi

Innihaldslýsing:Þorskalýsi, E-vítamín (d-alfa-tókóferýl asetat), A-vítamín (retínól palmítat), D-vítamín (kólekalsiferól).

Plokkfiskur

Innihaldslýsing: Ýsa 30%, vatn, kartöflur,laukur, *hveiti ,nýmjólkurduft,* smjörlíki transfitulaust (grænmetisolía (pálma og raps) bindiefni mono- og diglýseríð fitusýra, aroma, litarefni blönduð karótín), smjör, kartöflusterkja, jurtaostur (*mjólkurprótein*,jurtafita, *mjólkurfita,* sítrónusýra) kraftur (hydroliseruð grænmetisprótein (inniheldur*soyja*) grænmetisfita (pálma) krydd (inniheldur *sellery*)), karrý pipar, salt.

Fiskur í humarsósu

Innihaldslýsing: Fiskur 40%, humarsósa 40%:(fiskisoð(laukur, gulrætur, blaðlaukur, hvítvín, repjuolía, hvítlaukur), humarsoð (humarklær, tómatpúrra (tómatþykkni, salt, sítrónusýra), sítrónusafi (kaliumdisulfit), humarfond (mjólkursýra, kartöflusterkja, kalíumsorbat, rósmarín, majoram), koníak, kraftur (hydroliseruð grænmetisprótein (inniheldur *soyja*), grænmetisfita (pálma), krydd (inniheldur*sellerý*), svartur pipar, múskat, paprika, karrý, lárviðarlauf, stjörnuanis), *jurtarjómi*: (áfir, hert fita, bindiefni: E472b, E435, E433, bragðefni: stöðuleikaefni:carrageenan), *hveiti*, smjörlíki transfitulaust: (grænmetisolía (pálma og raps), bindiefni: mono-og diglýseríð fitusýra, aroma, litarefni: blönduð karótín), turmeric.

Fiskur í hvítlaukssósu

Innihaldslýsing: Fiskur 40%, hvítlaukssósa 40% (fiskisoð: *jurtarjómi*: (Áfir, grænmetisolía, hert fita (grænmetisolía) sterkja, bindiefni: E472b,E435, E433, bragðefni: stöðuleikaefni: carrageenan), smjörlíki transfitulaust: (grænmetisolía (pálma og raps), bindiefni: mono-og diglýseríð fitusýra, aroma, litarefni: blönduð karótín), *hveiti*, hvítvín, laukur, gulrætur, blaðlaukur, *sellerý,* olía, kartöflusterkja, hvítlaukur, kraftur (hydroliseruð grænmetisprótein (inniheldur *soyja*), grænmetisfita(pálma)), salt.

Fiskur í karrýsósu

Innihaldslýsing: *Fiskur* 40%, karrýsósa 40%: fiskisoð*(jurtarjómi*: (áfir, hert fita, sterkja, bindiefni: E472b, E435, E433, bragðefni: stöðuleikaefni: carrageenan), smjörlíki transfitulaust: (grænmetisolía (pálma og raps), bindiefni: mono-og diglýseríð fitusýra, aroma, litarefni: blönduð karótín), *hveiti,*hvítvín, laukur, gulrætur, blaðlaukur, *sellerý*, olía, kartöflusterkja, karrý, kraftur (hydroliseruð grænmetisprótein (inniheldur *soyja*), grænmetisfita(pálma), salt).

Appendix 2

Omega-3 oil

Ingredients: Fish oils, cold pressed olive oil and natural tocopherols antioxidants. Added vitamin D. The fish oils are produced in compliance with the quality regulations of the EU.

Table 16 Nutritional value for the omega-3 oil in 100 g

		Omega-3 oil
Energy	KJ	2640
	Kcal	630
Protein	%	10
Carbohydrates	%	34
Sugars	%	15
Ash	%	2.5
Moisture	%	2.5
Fat	%	51
FA profile:		
SFA	G	15.4
MUFA	G	22.9
Omega-9	G	18.3
PUFA	G	12.1
Omega-6	G	1.7
Omega-3	G	9.4
EPA	G	5.3
DHA	G	2.4
Dietary fibre	G	
Vitamin D	µg	40.7
Sodium	G	
Salt equivalent	G	

Appendix 3

Here are few questions about your purchasing habits and consumption (Try to base your answeres on the last 3 months prior to this study).

1. I buy fish or other fish products:

Never	1-4 times per year	5-8 times per year	Monthly	2-3 times per month	1x per week	2 times a week	3-4 time a week	Daily/almost daily
☐	☐	☐	☐	☐	☐	☐	☐	☐

2. I buy readty to eath fish dishes (like for example fish dishes in fish stores or ready to heat fish cakes):

Never	1-4 times per year	5-8 times per year	Monthly	2-3 times per month	1x per week	2 times a week	3-4 time a week	Daily/almost daily
☐	☐	☐	☐	☐	☐	☐	☐	☐

3. How often do you consume fish as a <u>main dish?</u>

Never	1-4 times per year	5-8 times per year	Monthly	2-3 times per month	1x per week	2 times a week	3-4 time a week	Daily/almost daily
☐	☐	☐	☐	☐	☐	☐	☐	☐

4. How often do you consume ready to eat fish dishes as a <u>main dish?</u>

Never	1-4 times per year	5-8 times per year	Monthly	2-3 times per month	1x per week	2 times a week	3-4 time a week	Daily/almost daily
☐	☐	☐	☐	☐	☐	☐	☐	☐

5. How frequently do you take vitamins, minerals or cod liver oil?

Never	Less than montly	Monthly	2-3 time per month	1x per week	2 times a week	3-4 time a week	Daily/almost daily	More than 1 time per day
☐	☐	☐	☐	☐	☐	☐	☐	☐

6. Do you observe informations like ingredients on food packaging?

Never	Seldom	Occasionally	Often	Always
☐	☐	☐	☐	☐

Appendix 4

Matís ohf
Vínlandsleið 12, 113 Reykjavík
Sími: 422 5000
Fax: 422 5001
kolbrun@matis.is

Questoinnaire associated to consumption of the meals in the research

Dear participant

In this survey we ask about feelings before, during and after consumption and liking of the meals.

Please noticie that you are not obligate to answer individual question in the list. We would however appreciate if you would be able to answer all the questions. The answers can not be traced back to individuals and your name will never occur in the processing of the data form the survey.

If you have any questions regarding the questions, the meals or the powder please contact Valgerður in telephone 691 9878 or through email valgerdur@matis.is

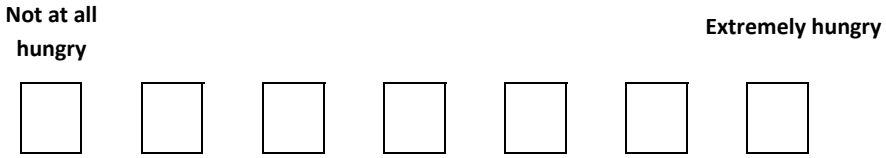
Participants number _____

Week 1/4

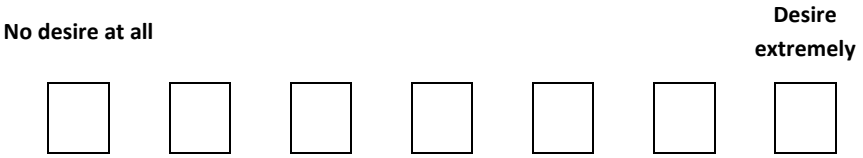
Name of the dish

Please answere the following questions befor consumption of the dish.

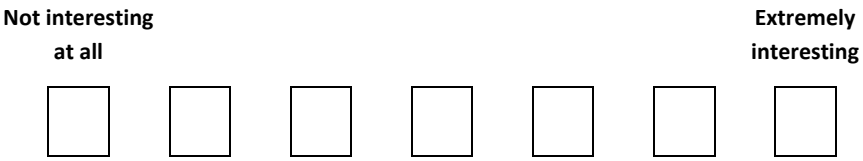
1. How full or hungry are you?



2. How much do you look forward to eat the dish?



3. How interesting do you think the taste of the dish is?



Please cook or heat the dish following the instructions on the packaging and then answer the following questions after the consumption.

4. How did you like the dish?

Very bad				Neither bad nor good				Very good
☐	☐	☐	☐	☐	☐	☐	☐	☐

5. Was something about the dish that you liked or disliked?

_____

_____

_____

6. How much of the dish did you eat (about)?

Nothing	1/4	Half	3/4	The whole meal
☐	☐	☐	☐	☐

7. Did you have desire to eat more of the dish in this mealtime?

No desire at all						Desire extremely
☐	☐	☐	☐	☐	☐	☐

8. Would you buy this product?

Very unlikely						Very likely
☐	☐	☐	☐	☐	☐	☐

9. Please state if you agree or don't agree with these three statements about preparation of the dish:

	Completely disagree						Agree completely
Simple	☐	☐	☐	☐	☐	☐	☐
Quick	☐	☐	☐	☐	☐	☐	☐
Convenient	☐	☐	☐	☐	☐	☐	☐

10. After consumption of the dish to what extent did you get boredwith the dish?

Extremely bored						**Not at all bored**
☐	☐	☐	☐	☐	☐	☐

11. How did you like theappearance of the dish?

Very badly						**Very well**
☐	☐	☐	☐	☐	☐	☐

12. How did you like the taste of the dish?

Very badly						**Very well**
☐	☐	☐	☐	☐	☐	☐

13. How did you like the texture of the dish?

Very badly						**Very well**
☐	☐	☐	☐	☐	☐	☐

14. At what time of they day did you consume the dish?

_____

15. Briefly describe your cooking method (e.g. heating in the oven, microwave or on the pan) and the side dishes – if applicable.

_____

_____

_____

16. Please state what you think after consumption of the dish.

After consumption of this dish I feel:

Light	☐	☐	☐	☐	☐	☐	☐	**Heavy**
Healthy	☐	☐	☐	☐	☐	☐	☐	**Unhealthy**
Unhappy	☐	☐	☐	☐	☐	☐	☐	**Happy**
Feel good	☐	☐	☐	☐	☐	☐	☐	**Feel bad**
Full of wholesomeness	☐	☐	☐	☐	☐	☐	☐	**Full of unwholesomeness**
Unpowerful	☐	☐	☐	☐	☐	☐	☐	**Powerful**
Full	☐	☐	☐	☐	☐	☐	☐	**Hungry**

17. Now you have recently finished consumption of the dish, how much desire do you have to consume the dish again after:

	No interest at all						**Very much interest**
3 days	☐	☐	☐	☐	☐	☐	☐
1 week	☐	☐	☐	☐	☐	☐	☐
2 weeks	☐	☐	☐	☐	☐	☐	☐
One month	☐	☐	☐	☐	☐	☐	☐

At the end we would like to ask you to answere the following questions and please keep in mind all the dishes consumed in this week.

18. Please rank the dishes you have consumed this week from 1 to 6 according to what dish you thought was the best (1) and what dish you thought was the worst (6).

Fish in white sauce ☐

Haddock in curry sauce ☐

Fish cakes ☐

Vegetable cakes ☐

Gratinated haddock with broccoli ☐

Haddock in lobster sauce ☐

19. Was something that happened that led to that you could not follow the plan as supposed to?

Yes ☐

No ☐

If yes, please note what it was that led to that you could not follow the plan:

_____

_____

_____

Comments?

_____

_____

_____

Appendix 5

Table 17 Results of the product evaluation of the enriched fish dishes from experiment 2

Sample	Appearance	Odour	Flavour	Texture
Fish in white sauce	Yellowish	Butter, onion, characteristic fish in white sauce odour, no off odour	Butter, curry, onion, little fish flavour, no off-flavour, nutmeg, white pepper	Rather small pieces of the fish, good texture of the sauce
Fish cakes	No comments on appearance	Frying odour, onion, no off-odour	Fish, onion, a bit salty, no off-flavour	Rather sticky, adhesive, potato starch but otherwise ok
Arctic char Fish cakes:	Heterogeneous and frying is uneven between samples	Ginger odour, bacon	Ginger, bacon, strong arctic char flavour, soy, coriander, different from other similar products, exciting flavour, could be good with noodles, no extra flavour, a bit salty	The cakes had rather loose texture, not dough like, you can detect fish, potatoes and more ingredients, a bit like omelette
Haddock in curry sauce	Very yellow, the sauce is runny, the sauce separates. normal appearance	Lemon, curry, no off-odour	Little salt, lemon, curry, no off-flavour, no signs of spoilage	No comment on texture
Haddock in garlic sauce	The sauce separates a little. Normal appearance	Garlic odour (garlic butter), no off-odour	Little salt, garlic flavour, sweet fish flavour, no off-flavour, no signs of spoilage	No comment on texture
Haddock in lobster sauce	Thickest of the three sauce, separates less Normal appearance	Lobster soup odour, burned cheese, no off-odour	Rather neutral flavour, tomato, little salt and spices, no signs of spoilage, no off-flavour	No comment on texture

Appendix 6

Table 18 Results of the product evaluation of Fish in white sauce and Gratinated haddock with broccoli with (O3) and without omega-3 oil enrichment from experiment 3

Sample		Appearance	Odour	Flavour	Texture
Fish in white sauce		Yellowish	Sweet, butter	Butter, onion, pepper	Soft, fish and potatoes well detected
	O3	More oil, otherwise little difference from sample without omega	A trace of vanilla (olive oil after tasting of the sample)	Olive oil flavour which was not of sample without omega.	No comments
Gratinated haddock with broccoli		Large pieces of fish and vegetables	Cauliflower soup, broccoli, asparagus, little salt	Cauliflower, broccoli, asparagus, little salt, no comments	No comments
	O3	More fat, more shiny than sample without omega	Olive oil odour	Very prominent olive oil flavour, less asparagus-, broccoli- and cauliflower flavour	More fatty texture than sample without omega

Table 19 Results of the product evaluation of Haddock in lobster- and curry sauce with (O3) and without omega-3 oil enrichment from experiment 3

Sample		Appearance	Odour	Flavour	Texture
Haddock in lobster sauce		No comments	Lobster, shellfish, no comments	Shellfish, fresh fish, sweet, some pepper	Very thick sauce
	O3	No comments	Different odour, less shellfish odour, trace of clove odour, no olive oil odour	Olive oil flavour, sweet, a bit more salt, caramel like flavour, olive oil flavour which could be defect	Thinner sauce
Haddock in curry sauce		Yellow- greenish color (strange color)	Curry odour, no comments	Rather neutral, mild curry, trace of olive oil flavour, less salt than samples 1 and 2	Fish rather dry
	O3	A bit more brown color than of sample number 3, a bit more normal color	Curry, turmeric, a slightly different smell than of sample number 3	More flavour than of sample 3, more curry flavour and a bit more salty	The sauce is thicker compared to sample number 3, s sticky fish rather dry (similar to sample number 3)

Table 20 Results of the product evaluation of Fish cakes and Vegetable cakes with (O3) and without omega-3 oil enrichment from experiment 3

Sample		Appearance	Odour	Flavour	Texture
Fish cakes		No comments	Frying odour, dill	Mild flavour, a bit salt, dill, pepper, onion, no comments	A little as the texture of omelets
	O3	No comments	More onion odour, no comments	More flavour than of sample number1, more pepper, more dill, no comments	Bigger pieces of potatoes and onion, similar texture
Vegetable cakes		No comments, a bit wet (sweaty)	Pepper, vegetable mix, sweet odour, frying odour, no comments	Sweet pepper, beans, vegetables, pepper, not much salt, no comments	Rather loose texture compared to cakes, no comments
	O3	No comments, similar to sample 3	Odour similar to sample number 3, more spice (curry, turmeric), no comments	Sweet, a bit less pepper flavour, more bean flavour, more spice flavour (curry like), no comments	Texture similar to the texture of sample 3, no comments

Appendix 7

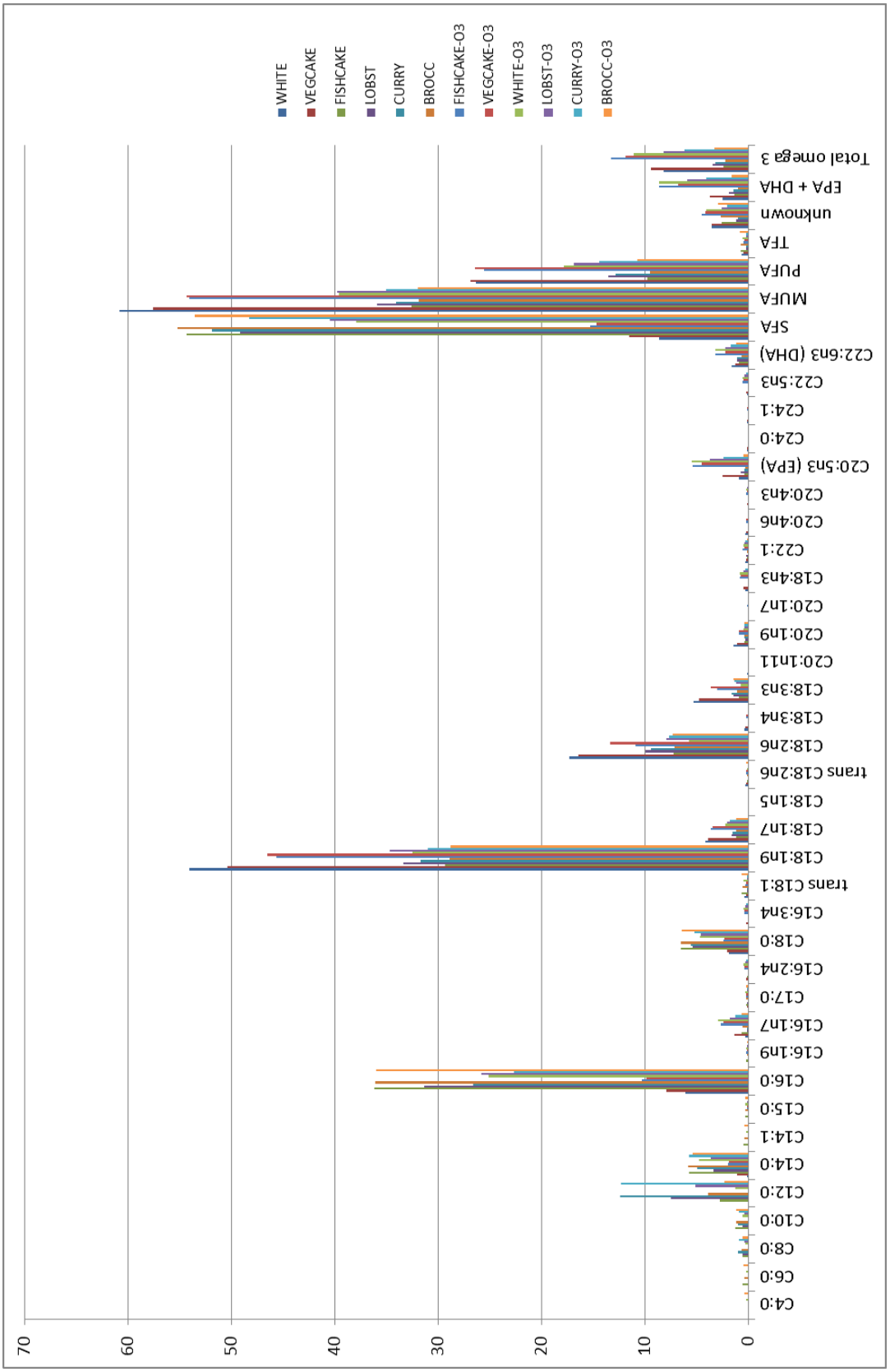


Figure 6 The fatty acid profile of the 12 prototypes from experiment 3.

Appendix 8

Table 21 Results of the PV measurements of the 12 prototypes from experiment 3 (see sample code in table 3).

Sample	Month 0	Month 3	Month 6
Fish in white sauce	0.0233±0.003	0.0498±0.006	0.0388±0.003
Fish in white sauce O3	0.0367±0.002	0.0674±0.009	0.0847±0.001
Gratinated haddock with broccoli	0.0011±0.020	0.0728±0.034	0.0627±0.008
Gratinated haddock with broccoli O3	0.0003±0.002	0.0704±0.009	0.0840±0.004
Haddock in lobster sauce	0.0008±0.014	0.0714±0.009	0.0432±0.010
Haddock in lobster sauce O3	0.0036±0.005	0.0935±0.003	0.0811±0.001
Haddock in curry sauce	0.0006±0.003	0.0950±0.014	0.0975±0.004
Haddock in curry sauce O3	0.0016±0.002	00957±0.028	0.0947±0.014
Fish cakes	0.0050±0.003	0.0409±0.031	0.0712±0.013
Fish cakes O3	0.0393±0.012	0.0424±0.010	0.0459±0.005
Vegetable cakes	0.0489±0.016	0.0692±0.003	0.1447±0.019
Vegetable cakes O3	0.0501±0.002	0.0861±0.006	0.1221±0.004

Table 22 Results of the TBARS measurements of the 12 prototypes from experiment 3 (see sample code in table 3).

Sample	Month 0	Month 3	Month 6
Fish in white sauce	0.0069±0.0004	0.0392±0.0033	0.0897±0.0189
Fish in white sauce O3	0.0085±0.0007	0.0847±0.0270	0.0773±0.0144
Gratinated haddock with broccoli	0.0096±0.0006	0.0598±0.0023	0.0729±0.0142
Gratinated haddock with broccoli O3	0.0097±0.0006	0.0636±0.0141	0.0782±0.0227
Haddock in lobster sauce	0.0069±0.0015	0.0754±0.0234	0.0693±0.0260
Haddock in lobster sauce O3	0.0071±0.0007	0.0630±0.0026	0.0627±0.0086
Haddock in curry sauce	0.0076±0.0005	0.0345±0.0052	0.0598±0.0163
Haddock in curry sauce O3	0.0081±0.0007	0.0392±0.0027	0.0509±0.0076
Fish cakes	0.1419±0.0235	0.0826±0.0059	0.1052±0.0060
Fish cakes O3	0.1095±0.0062	0.0884±0.0032	0.1096±0.0049
Vegetable cakes	0.4185±0.0066	0.3636±0.0150	0.4860±0.0672
Vegetable cakes O3	0.4524±0.0113	0.3599±0.0270	0.6337±0.0745

Appendix 9

Table 23 Comments on if there was something liked or disliked for fish in white sauce.

Week 1 **Omega-3 group**	**Week 4** **Omega-3 group**
Fannst ekki nóg af fisk í honum, of mikið af sósunni	Finnst voða lítið af fiski í þessu
Fannst hann of þunnur og frekar slepjulegur. Hefði viljað finna meira fyrir alvöru fiski og kartöflum	Finnst hann of mikið fljótandi ætti að vera meiri fiskur og kartöflur
Finnst plokkfiskur yfirleitt góður. Í þessum rétti hefði ég viljað finna meiri fisk og minna af hveiti	Bragðgóður
Bragðgóður, mætti vera bragðsterkari. Of lítið af fisk í honum	Vantaði substance
Rjóma kenndur og góður	Bragðgóður og mjög áhugaverður
Alveg fín	Áferð og bragð
Rétturinn var bragðgóður en mér líkar yfirleitt ekki við mat sem er svona í kássu	Góður
Litur á réttinum dálítið gulur	Frekar bragðlaus
Svolítið sætur, ekki nóg fiskibragð	Vantar meiri fisk
Vondur, ég elska plokkfisk en þessi var bara vondur	
Hefði mátt finna fyrir fiskinum	
Hann var góður og ég fýla hann vel	
Of mikil olíubrák ofaná honum þegar hann var tilbúinn	
Control group	**Control group**
Vantaði lauk+pipar	Vantaði meiri lauk
Hann var nokkuð bragðgóður en hefði mátt vera meiri laukur, eins og hjá mömmu	Mjög góður
Góður réttur, kannski heldur mikið kryddað	Mætti vera aðeins bragðmeiri
Nei, bætti svolitlum osti og bernessósu og þá var hann frábær	Mér finnst heldur mikið af sósu miðað við fisk eða of lítill fiskur miðað við sósu
200 gr of lítið í réttin	Of salt
Eins og heimatilbúinn plokkfiskur	Plokkfiskurinn er vel heppnaður
Nei	Of mikið af kartöflum, meira en mér hefur fundist áður (sem er sennilega rangt)
Þetta var mjög fínn plokkfiskur sem ég kaupi oft. Það mætti að ósekju vera aðeins meiri fiskur í honum	Of mikið af sósu miðað við fisk
Of saltur, of lítill fiskur, of mikið gums. Annars ok	Of þykkur/límkenndur, mætti vera meira krydd
Hefði mátt vera bragðmeiri(saltað)	
Nei	
Sá lítið af fiski! Vil vita hvað er í rétti sem þessum	
Of kryddaður	
Hefði mátt pipra meira	
Bragðgóður en frekar mikið af kartöflum ekki nákvæm innihaldslýsing	
Plokkfiskur í uppáhaldi hjá mér. Líkaði bara mjög vel við réttinn	
Of mikið mauk	
Allt of lítill fiskur of mikið hveiti. Minnti á þykka hveitisósu (uppstúf) með slatta af pipar var hægt að borða þetta með rúgbrauði.	
Bragðgóður	
Rétturinn var mjög góður	

Table 24 Commont about if there were something they liked or disliked for fish cakes.

Week one **Omega-3 group**	**Week four** **Omega-3 group**
Fannst þær bara mjög bragðgóðar	Orðinn frekar leiður á þeim. Borða almennt ekki unnar matvörur
Svolítið mikið salt og þurrar	Rétturinn var góður
Er vandlátur á fiskibollur og finnst þær yfirleitt ekki góðar, nema heimatilbúnar. Fannst þessar ágætar en of mikið hveiti-eitthvað?	Mikið salt í þessu var ekki hægt að borða alla
Bragðgóðar, mjög góðar	Ekkert sérstakt, mér finnast fiskibollur ekkert sérstaklega góður matur
Var bara góður	Aðeins of mikið mjöl/bindiefni
Bragðið	Bragð
Of mjúkar, mættu vera stökkar	Bara góður
Nei, en fannst skrítið að sjá kartöflur í bollunum	Bragðgóður
Ekkert fiskibragð. Bara eins og að borða þéttmauk. En stærðin og útlitið (að utan) leit vel út eftir á að hyggja var þetta eins og plokkfiskurinn bara Pressaður saman.	Ekkert spennandi við þessar bollur. Ekki eins og maður sé að borða fisk
Góðar á bragðið en ég fékk brjóstsviða - á það til eftir að ég borða fiskibollur (ef laukur í þeim)	
Control group	**Control group**
Mér fannst þær frekar þurrar en bragðgóðar	Frekar þurrar bollur
Vantaði meðlæti, grænmeti og kartöflur. Sósan var þó góð. Bollurnar voru bragðgóðar en þurrar	Nei. Væri nóg að borða 2 bollur í mál
Mér fannst þessar bollur nákvæmlega eins og ég vil hafa þær. Enda eru fiskibollur uppáhaldmaturinn minn og mér er ekki sama hvernig þær eru gerðar. Fiskibragðið en ekki bragð af hveiti	Bollurnar eru aðeins í saltari kantinum fyrir minn smekk
Bragðgóðar	Of saltar
Bragðlítið	Frekar bragðlitlar
Spurning um að krydda þær aðeins meira	Bollurnar voru bragðgóðar en frekar þurrar
Fannst þær sterkar of mikið? Kannski pipar bragð. Ekki viss	Þetta eru mjög góðar bollur með passlegu magni af fiski
Mjög gott	
200g réttur er lítill skammtur	
Betra að hita bara í örbylgju	
Nei	
Nei	
Mér fannst bollurnar mjög góðar en ég var ekki fullkomlega frísk og hafði þess vegna ekki mikla matarlyst	
Svona á 3-4 bollu fannst mér þær þurrar/kornóttar en það stoppaði mig ekki	
Nei	
Allt of saltar, svolítið þurrar	
Nei, vantaði meiri sósu	
Lítill fiskur, mikið mjöl	
Þurrar og bragðlitlar	
Mjög góðar bollur	
Eitthvað krydd (basil)	
Að vita ekki innihaldið	
Mjög gott	
Nei	
Nei	
Nokkuð bragðgóður en of þéttar, þ.e. Of fínt hakkaður fiskur og of mikið hveiti eða bindiefni	
Sérstaklega bragðgóðar, mikið magn af fiski vs. Hveiti gott krydd	

Table 25 Commont about if there were something they liked or disliked for haddock in curry sauce.

Week one **Omega-3 group**	**Week four** **Omega-3 group**
Fannst allt of mikið af sósu	Búin að fá leið á þessu
Líkaði mjög vel að sjá alvöru fisk í réttinum, þrátt f. Mikla sósu	Mér finnst þetta frekar klígjugjarnt svona fiskur í sósu. Er búin að fá of mikið af því góða með að borða þetta í fjórar vikur í röð
Nei en mætti vera meira krydd	Of mikið af sósu og "gumsi"
Of mikil olíubrák	Var bara ekkert hrifin
Dálítið mikið sterk	Olíubrák, þykk sósa og ekki gott
Of mikil sósa	Of mikil sósa
Prýðis matur	Mætti vera meira karrý bragð
Nei	Góður matur
Góður	Frekar bragðlaus
Þetta var mjög svo ljúffengur réttur	Áferð - slímkennd
Sósan aðeins of þykk	Góður
Sósan flaut ekki - var of þykk eftir eldunartímann	
Hefði viljað finna örlítið meira karríbragð	
Control group	**Control group**
Fiskurinn var ok, en sósan ógeðsleg	Eins og í fyrstu viku hefði ég viljað finna meira karríbragð
Mjög mildur réttur, hefði kosið sterkara karrýbragð	Eitthvað svo ógeðslegur í fitugri sósunni
Ekki nógu mikið	Áferðin var frekar slepjuleg
Hefði mátt vera örlítið meira kryddaður	Líkaði vel. Finnst of stórir skammatar í einu
Sósan þykk og væmin eiginlega ógeð! Fiskurinn ekki spennandi	Of mikil sósa, of lítill fiskur
Ljómandi fínt	Örlar við að vera dálítið væminn
Of lítill skammtur sem aðalmáltíð	Mikil sósa
Góð sósa, mætti vera minni sósa og meiri fiskur	Sósan var of mikil, of þykk og eitthvað aukabragð sem hefur ekkert með karrý að gera
Mjög góður	Það er allt of mikið af sósu gat ekki borðað hana alla en fiskurinn var mjög góður
Vantaði meira krydd	Allt of mikil sósa. Ég er mjög hrifinn af fisk í sósu úr fiskbúð en þetta er afleitt. Fiskurinn sjálfur af góðum gæðum
Sósa var of mikil og þykk. Einnig var of mikið af henni. Forbragð lítið betri bragð	Of mikil sósa, of salt, smá frystigeymslu bragð og áferð
Sósan er góð á bragðið og passar vel við fiskinn en það er allt of mikið af henni og hún er þykk. Spillir líka útliti	Þurfti að bragðbæta undir það síðasta
Sósan var ótrúlega slepjuleg og þykk. Bragðið var gott en heildar áhrifin líða fyrir sósuna. Ég skildi hana eftir því það var allt og mikið af henni (100 gr eftir)	Ógirnilegur/slepjulegur
Hlutfall sósu allt of mikið (50%) fiskurinn góður og nýr þegar frystur. Eftir að sósan hefur verið fryst þá eru gæði hennar ekkert lík fiski í sósu úr fiskbúð	Að vita ekki hvaða efni sósan inniheldur og hún lítur ekki vel út í pakkningunni og er frekar þykk
Full mikil sósa (borðaði lítið af henni, en kláraði fiskinn), full salt, góður fiskur	Of mikið af sósu
Fiskurinn sjálfur var furðu góður	Of þykk sósa og bragðlaus
Já fann svart hár í matnum og gat ekki borðað meira!	Sósuhatturinn er ógeðslegur
Lítið bragð	Slepjulegur
Ólystugur	
Ívið of saltur	
Mætti vera meira salt	
Hefði átt að sjóða mér kartöflur með	
Of mikið af sósu, annars fínt	
Bragðlaust. Fiskurinn of fastur í forminu og erfitt að ná honum úr án þess að hann færi í mauk. Sósan of þykk	
Þessi sósa er ekki sósa, meira svona eins og frauðplasthattur ofnaá fiskinum	
Of mikil sósa	

Table 26 Commont about if there were something they liked or disliked for gratinated haddock with broccoli.

Week one **Omega-3 group**	**Week four** **Omega-3 group**
Bragðmikill	Of þunnt
Mér fannst hann bara mjög góður	Bragðgóður
Kom á óvart að um plokkfisk væri að ræða og hefði ekki vitað að um brokkolí væri að ræða nema af því það stóð á umbúðunum. Þetta á við þó ég væri búinn að borða matinn	Vantar sterkara bragð
Var eins og plokkfiskur og mér líkaði hann og líkaði þessi réttur betur en plokkfiskurinn um daginn. Var mjög svangur sem hefur eflaust áhrif. Hefði viljað sjá meira af fiski og brokkoli.	Fínasti matur
Hefði viljað finna meira fyrir fiskinum í réttinum	Skásti rétturinn
Mér fannst áferðin ekki falleg hefði viljað aðeins grófara , svolítið bragðlaust	Nokkuð vel
Of mikið mauk fyrir minn smekk	Lítill fiskur
Ekki hrifin af ýsu!	
Ágæt upplifun	
Hann var bara ljúfur	
Áferðin ekki skemmtileg	
Bara góður	
Vantaði meira af spergilkáli. Finnst ég alltaf ver að borða sama réttinn	
Mér fannst þa'ð vera of kássulegt	
Ég fann ekki ýsuna	
Þurfti að salta smá (set venjulega lítið salt á mat).	
Control group	**Control group**
Ólystugt, brá fyrir lýsislykt	Ég hitaði hann í potti, aðeins of lengi :(
Sósan sem ég prófaði með réttinum heillaði mig ekki	Góður réttur
Bragðgóður	Of mikil sósa, of lítill fiskur
Ekki nógu mikið	Of mikið brokkolí, mætti vera fl grænmeti t.d. Gulrætur
Sósan of þykk - brokkolíið mætti vera í stærri bitum og lítill fiskur	Dálítið mikil sósa miðað við fisk
Góð en bragðlítil	Svolítið mikið gums
Of lítið af fiski, of mikið af sósu - mauk	Mjög góður réttur. Mætti var aðeins hærra hlutfall af fisk
Mjög gott	Of salt
Mjög góður	Betri en mig minnti, brokkolíið ekki í eins stórum bitum og áður
Mjög góður réttur, eiginlega betri en hefðbundinn plokkfiskur	Rétturinn mætti vera bragðmeiri t.d. Meiri pipar. Svolítið límkenndur sem gerir réttinn frekar ólystugan
Of mikið maukað	Ég elska allt með brokkolí
Nýstárleg bragð á plokkfiski. Góður réttur	
Of salt, of lítið brokkoli	
Ansi líkt plokkara	
Sósan	
Nei	
Of lítill fiskur í réttinum	
Nei	
Of saltur	
Smakkaðist bara vel. Hefði mátt vera meira kál.	
Of maukaður	
Of mikið mauk og mikið smjörbragð	
Mætti innihalda meiri fisk, upphitunartíminn á umbúðum er of stuttur	

Table 27 Commont about if there were something they liked or disliked for vegetable cakes.

Week one **Omega-3 group**	**Week four** **Omega-3 group**
Bragðlaust	Leiðigjarnt bragð
Mér finnst hann líta ferlega illa út frosin, eitthvað voð mikið af fitu og bara alls ekki girnilegt. Sorry	Fannst eitthvað skrítið bragð, og ótrúlega mikil olía eða fita á þessu
Bragðið ekkert sérstakt en ef drekt með sósunum þá allt í lagi	Mér finnst vera e-ð óspennandi væmið eftirbragð
Er hlutlaus gagnvart grænmetisbollunum. Döðlumaukið og jógúrtsósan björguðu í raun réttinum f. Mig	Þær m ættu vera bragðmeiri. Minntu dálítið á steiktar kartöflur
Mér finnst bragðið vera væmið	Of rammar
Mér finnst svolítið mikið salt	Ágætur
Ekki gott	Góður
Góð upplifun	Rétturinn var góður
Nei	Fannst þær svolítið linar
Frekar linar	Hefði viljað vita innihalsdlýsingu
Hefði mátt sleppa döðlumaukinu	
Mjög bragðgóður, dálítið lausar í sér bollurnar	
Cotnrol group	**Control group**
Mjög bragðgóðar	Finnst ekki gott að hafa grænar baunir í réttum. Of mikið að borða 4 bollur
Vantaði kjötið...	Það vantaði eitthvað í hann annars er ég lítið fyrir grænmetisrétti
Góð samsetning og mátulega kryddað . Kannski bara með fersku salati en hrísgrjónum þar sem hrísgrjón eru í bollunum	Lausar í sér
Þetta var ágætt sérstaklega með sósunni	Heldur lausar í sér
Mjög gott	Er mjög lítið fyrir 100% grænmetisrétti
Virkilega góðar	Of salt
Mér fannst jógúrtsósan passa mjög vel við en döðlumaukið ekkert eiga sérstaklega vel við	Slepjulegar
Nei	Grænar baunir vaondar ser eni í þeim
Full salt, bestu grænmetisbuff sem ég hef smakkað	Besta á matseðlinum
Áferðin - of mjúkt í miðju	Að vita ekki hvað varn inniheldur og bollurnar frekar blautar
Varð ekki saddur	Sósan gerir réttinn mjög góðan
Hef aldrei verið sérstaklega hrifin af grænmetisréttum né grænmeti	Eini rétturinn sem er það góður að ég myndi kaupa hann í búð. Jógúrtsósan einnig mjög góð
Nei	Algjört sælgæti
Baunirnar grænu heilu	Ekki áhugaverðar, lausar í sér
Nei	
Skar af skaðbrennda húð áður en þær fóru í ofninn	
Bollurnar voru góðar og minntu mig á hnetusteik móður náttúru. Jógúrt sósan passaði líka vel við en döðlumaukið er of sætt fyri rminn smekk. Sólskynssóan frá móður náttúru passar örugglega með bollunum líka.	

Table 28 Commont about if there were something they liked or disliked for haddock in lobster sauce.

Week one **Omega-3 group**	**Week four** **Omega-3 group**
Aðeins of mikil sósa	Of mikil sósa
Enn og aftur allt of mikið af sósu, rétturinn annars ágætur	Er bara því miður búin að fá leið á þessu
Líkaði að sjá stórt fiskistykki í réttinum	Er búin að borða það sama í 4 vikru og er komin mera en nóg af þessu er ekki fyrir fisk í sósu
Bragðið var mjög gott	Mér finnst bragðið ekki spennandi fyrir minn smekk
Fiskurinn góður en sósan vond	Of mikið jukk ofaná
Mér fannst of mikil sósa með	Mjög góður
Ánægjuleg upplifun	Of mikið humarskeljabragð
Sósan hefði mátt vera bragðmeiri en góð	Góður og hollur
Ég er með óþol fyrir skelfiski og tók því sósuna frá eisn og hægt var	Létt gott bragð
Of mikil sósa	Svo sem allt í lagi
Fannst sósan góð en of mikið af henni	Góður
	Sósan vond
	Gamall og þurr fiskur
Control group	**Control group**
Nei, miðað við fullunninn rétt þá var hann alveg fyrirtak	Mjög góður nýr fiskur
Ekki nógu mikið	Slepjulegur
Eitthvað slepjulegur	Gat ekki hugsað mér að borða e. 1. skiptið
Væmið bragð	Finnst humarsósa ekki passa vel
Ógeðsleg sósa og fiskurinn orðinn óspennandi	Nei bjóst samt við einhverju meira
Sérkennileg sósan, samt ekki vont, dálítið mikill fiskur	Of mikil sósa
Ljómandi gott	Dálítið væmin
Það var bein í matnum, svona stórt, mjög hættulegt	Of mikil sósa
Væminn	Já humarsósan
Of mikil sósa, lítill fiskur, það var nánast ekkert humarbragð af sósunni en hún var samt mild	Sósan of þykk. Svo var lokbragð. Sem er nær spenndi
Mjög góðar	Sósan er of mikil miðað við fiskinn en hún er mjög góð þannig að það liggur við að maður geti boraðað hana eintóma ogen ´g skildi samt smá eftir
Vantar meira bragð	Sósan er svo þykk
Eftirbragð í sósunni var væmið. Sóa of þykk	allt of mikil og vond sósa.Ekki að gera sig þessi réttur góð gæði á fisknum sjá
Mér fannst sóasn mjög góð og passa vel við fiskinn en mér fannst allt of mikið af henni svo ég skildi dálítið eftir	Of mikil sósa. Fiskurinn of saltur og frystigeymslubragð komið
Sósan sem mér þykir ekki líkjast sósu er eins og lím-búðingur. Hún hangir niður af gaflinum og slitanr ekki af þó maður hristi gaffalinn	Fiskurinn var ekki góður - geymslubragð
Hlutfall sósu allt of mikið. Áferð sósu ssvo lítið frauðkennt. Ekki sambærilegt og fiskur í sósu úr fiskbúð. Sósan er ekki að gera sig. Góður fiskur	Sósa ofaná vond, mjög ógirnileg
Nei	Sósan var hlaupkennd
Ýsan var ekki mjög góð (joð-bragð) of mikil sósa, kláraði næstum. Of mikið tómatbragð	Fiskur ekki góður í humars (ekki nýr)
Nokkur bein. Of mikil sósaþ Fiskurinn sjálfur nokkuð góður	Humarsósan ekkert spes
Sósan ofaná bragðgóð en klíuleg	Sósan er þykk og límkennd.Fiskurinn var þokkaleg ferskur
Sósan frekar þykk	Hvað er með þessa ekki sósu
Smakkaðist vel	Bragðlítill
Sósan ekki eins góð og ég bjóst við	Ekki góður
Bragðgóð sósa og fiskurinn fékk að njóta sín (ekki í mauki)	
Fiskurinn var góður og sósan bragðgóð en of þykk	
Já "sósan" mjög ógirnilegt, þetta var allt í lagi bragð en þessi kekkur er ekki girnilegur	
Ekki nógu bragðbóður	
Slepjulegur og ekki bragðgóður	

Appendix 10

Fish in white sauce

In the first week, 13 comments for the omega-3 enriched fish in white sauce dish and 20 comments for the conventional dish were made, but only nine comments for each group in week four. The comments are shown in table 18 in appendix 6. Most of the comments were regarding too much sauce and lack of fish pieces. Other comments were regarding too spicy or not enough spicy dish. No apparent differences were observed between omega enriched and conventional fish in white sauce nor between weeks.

Gratinated haddock with broccoli

For gratinated haddock with broccoli 16 comments were made in the first week for the omega-3 enriched gratinated haddock with broccoli and 23 comments for the conventional dish. In the fourth week seven comments were made for the omega-3 enriched but 11 comments for the conventional dish. The comments are shown in table 20 in appendix VI. Most of the comments were regarding too much sauce or mash and that it lacked fish pieces and then comments regarding the dish being too spicy or salty or it was not spicy enough. There were also many comments regarding the dish being tasty. No apparent differences were observed between omega enriched and conventional gratinated haddock with broccoli nor between weeks.

Haddock in curry sauce

For haddock in curry sauce 13 comments were made in the first week for the omega-3 enriched haddock in curry sauce and 26 comments for the conventional dish, but in the fourth week 12 comments were made for the omega-3 enriched dish and 17 comments for the conventional group. The comments are shown in table 21 in appendix 8. Most of the comments were regarding too much sauce and the sauce being too thick. Some mentioned they would like to have more curry taste and salt. More comments regarding thick sauce were made for the conventional dish. No apparent differences were observed between weeks.

Haddock in lobster sauce

For haddock in lobster sauce 11 comments in the first week regarding the omega-3 enriched haddock in lobster sauce dish and 28 comments for the conventional dish. In the fourth week, 13 comments were made for the omega-3 enriched dish but 23 for the conventional dish. The comments are shown in table 21 in appendix 8. Most of the comments were regarding too much sauce and the sauce being too thick and jelly like. There were more apparent comments regarding the sauce being too thick in the conventional dish compared to the omega-3 enriched. No apparent differences were observed between weeks.

Fish cakes

For fish cakes 10 comments were made in the first week for the omega-3 enriched fish cakes and 27 comments for the conventional fish cakes. In week four, nine comments were made for the omega-3 enriched seven for the conventional fish cakes. The comments are shown in table 22 in appendix 8. Most of the comments were regarding too dry fish cakes (the conventional group). No apparent differences were observed between weeks.

Vegetable cakes

For vegetable cakes, 12 comments were made in the first week for the omega-3 enriched vegetable cakes and 17 comments for the conventional vegetable cakes. In week four 10 comments were made regarding the omega-3 enriched group, but 14 for the conventional group. The comments are shown in table 23 in appendix 9. Most of the comments were regarding the omega-3 enriched cakes being too loose in texture and the cakes fell easily apart. No apparent differences were observed between weeks regarding the comments

Appendix 11

Table 29 Feeling of hunger in week one and four for both the omega-3 group and the control group. "How full or hungry are you?" Scale (1-7): 1 = Not at all hungry, 7= Extremely hungry.

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average(Sd)		N	Average(Sd)		N	Average(Sd)		N	Average(Sd)	
Fish in white sauce	27	5.1	(1.4)	52	4.8[b]	(1.5)	25	5.2	(1.2)	47	5.4[b]	(1.2)
Gratinated haddock with broccoli	27	5.6[a]	(0.8)	51	4.6[a,b]	(1.5)	25	5.3	(1.5)	49	5.5[b]	(1.2)
Haddock in curry sauce	27	5.6[a]	(0.9)	52	4.5[a,b]	(1.7)	26	5.3	(1.4)	49	5.3[b]	(1.6)
Haddock in lobster sauce	27	5.3	(1.2)	51	4.8	(1.6)	25	5.6[a]	(1)	46	5[a]	(1.2)
Fish cakes	27	5.5[a]	(1.1)	51	4.7[a]	(1.5)	26	5.5	(1.2)	48	5.2	(1.6)
Vegetable cakes	27	5.4	(1.6)	52	5.0	(1.7)	26	5.6	(1.3)	47	5.2	(1.4)

[a] Significant difference between the omega-3 group and the control group.

[b] Significant difference between week 1 and week 4.

Table 30 Estimate of how interesting the taste of the dish was in week one and four for both the omega-3 group and the control group. "How interesting do you think the taste of the dish is?" Scale (1-7): 1 = Not at all interesting, 7= Extremely interesting.

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average(Sd)		N	Average(Sd)		N	Average(Sd)		N	Average(Sd)	
Fish in white sauce	27	5.2	(1.3)	52	5.3	(1.4)	25	5.2	(1.4)	47	5.6	(1.4)
Gratinated haddock with broccoli	27	5.4	(1.3)	51	5.3	(1.5)	25	5.3	(1.2)	49	5.6	(1.5)
Haddock in curry sauce	27	5.7	(1)	52	5.4[b]	(1.4)	26	4.9	(1.7)	49	4.7[b]	(1.6)
Haddock in lobster sauce	27	5.9[b]	(1)	51	5.6[b]	(1.2)	25	4.5[b]	(1.8)	46	4.6[b]	(1.9)
Fish cakes	27	5.1	(1.5)	51	5.2	(1.4)	26	5.2	(1.6)	48	5.5	(1.2)
Vegetable cakes	27	5.3	(1.6)	52	5.6	(1.6)	26	4.9	(1.5)	47	5.6	(1.5)

[a] Significant difference between the omega-3 group and the control group.

[b] Significant difference between week 1 and week 4.

Table 31 Desire to consume the dishes in week one and four for both the omega-3 group and the control group. "How much do you look forward to eat the dish?" Scale (1-7): 1 = No desire at all, 7=Desire extremely.

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average(Sd)		N	Average(Sd)		N	Average(Sd)		N	Average(Sd)	
Fish in white sauce	27	5.4	(1.4)	52	5.8	(1.2)	25	5	(1.6)	47	5.7	(1.5)
Gratinated haddock with broccoli	27	5.7	(1)	51	5.3	(1.2)	25	5.2	(1.4)	49	5.8	(1.4)
Haddock in curry sauce	27	5.5	(1.5)	52	5.2	(1.4)	26	5	(1.9)	49	4.7	(1.8)
Haddock in lobster sauce	27	5.5[b]	(1.1)	51	5.4[b]	(1.6)	25	4.5[b]	(1.8)	46	4.5[b]	(1.8)
Fish cakes	27	5.5	(1.2)	51	5.3	(1.6)	26	5	(1.6)	48	5.5	(1.2)
Vegetable cakes	27	5.4	(1.7)	52	5.8	(1.3)	26	5[a]	(1.5)	47	5.3[a]	(1.7)

[a] Significant difference between the omega-3 group and the control group.

[b] Significant difference between week 1 and week 4.

Appendix 12

Table 32 Liking of appearance, taste and texture of the dishes in week one and four for both the omega-3 group and the control group. "How did you like; the appearance, the taste and the texture of the dish?" Scale (1-7): 1= dislike very much, 7= like very much.

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average	(Sd)	N	Average	(Sd)	N	Average	(Sd)	N	Average	(Sd)
Appearance												
Fish in white sauce	27	5.2	(1.6)	51	5.7	(1.3)	25	5.2	(1.5)	47	5.8	(1.4)
Gratinated haddock with broccoli	27	5.3	(1.7)	51	5.3	(1.6)	25	5.4	(0.9)	48	5.5	(1.4)
Haddock in curry sauce	27	5.5[a]	(1.3)	52	4.4[a]	(2.1)	26	4.9	(1.8)	49	4.3	(1.9)
Haddock in lobster sauce	27	6[a.b]	(1.1)	51	4.6[a]	(2)	25	4.9[b]	(1.9)	45	4.7	(1.8)
Fish cakes	27	6.1	(1.1)	51	5.9	(1.4)	26	5.7	(1.4)	49	5.9	(1.2)
Vegetable cakes	27	5.6	(1.6)	52	6.1	(1.2)	26	5.8	(1.5)	47	5.7	(1.7)
Taste												
Fish in white sauce	27	5.5[a]	(1.5)	51	6.2[a]	(1.1)	25	5.4[a]	(1.5)	47	6.2[a]	(1.1)
Gratinated haddock with broccoli	27	5.4	(1.7)	51	6	(1.2)	25	5.2[a]	(1.5)	48	5.9[a]	(1.3)
Haddock in curry sauce	27	5.9[a.b]	(1.1)	52	5.2[a]	(1.9)	26	4.9[b]	(2)	49	4.8	(2.1)
Haddock in lobster sauce	27	5.6[b]	(1.4)	51	5	(1.7)	25	4.4[b]	(2.1)	45	4.6	(1.8)
Fish cakes	27	5.3	(1.7)	51	5.8	(1.6)	26	5.3	(1.6)	49	5.7	(1.2)
Vegetable cakes	27	5.5	(1.6)	52	6.1[b]	(1.3)	26	5.2	(1.7)	47	5.5[b]	(1.9)
Texture												
Fish in white sauce	27	4.7[a]	(1.8)	51	5.9[a]	(1.3)	25	5.2[a]	(1.6)	46	6[a]	(1.4)
Gratinated haddock with broccoli	27	5	(1.9)	51	5.4	(1.8)	25	5.2	(1.4)	48	5.5	(1.6)
Haddock in curry sauce	27	5.3	(1.4)	52	4.8	(2)	26	5	(1.9)	49	4.4	(2.1)
Haddock in lobster sauce	27	5.4[a.b]	(1.4)	51	4.2[a]	(2)	25	4.6[b]	(1.6)	45	4.3	(1.8)
Fish cakes	27	5.7	(1.5)	51	5.8	(1.6)	26	5.6	(1.6)	49	5.7	(1.3)
Vegetable cakes	27	5.6	(1.7)	52	6	(1.3)	26	5.7	(1.4)	47	5.6	(1.8)

[a] Significant difference between the omega-3 group and the control group.

[b] Significant difference between week 1 and week 4.

Appendix 13

Table 33 Desire to consume more of the dish for all the dishes in week one and four for both the omega-3 group and the control group. "Did you have any desire to eat more of the dish?" Scale (1-7): 1= No desire at all, 7= Desire extremely.

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average(Sd)		N	Average(Sd)		N	Average(Sd)		N	Average(Sd)	
Fish in white sauce	27	2.4[a]	(1.9)	51	3.4[a]	(2)	25	2.2[a]	(1.6)	46	3.6[a]	(2)
Gratinated haddock with broccoli	27	2.6	(1.9)	50	3.5	(2.2)	25	2.7[a]	(2.1)	48	3.8[a]	(2.1)
Haddock in curry sauce	27	2.8	(2)	52	3	(2)	26	2.1	(1.6)	48	2.8	(1.9)
Haddock in lobster sauce	27	2.6	(2)	51	3.2	(2.1)	25	2.3	(2.1)	45	2.6	(1.8)
Fish cakes	27	2.6	(2.1)	50	3.3	(2.3)	26	2.2[a]	(1.7)	49	3.2[a]	(2.1)
Vegetable cakes	27	2.2[a]	(1.8)	51	3.6[a]	(2.1)	26	2.7	(2.1)	47	3.4	(2.2)

[a] Significant difference between the omega-3 group and the control group.

Table 34 Boredom of consumption of dishes in week one and four for both the omega-3 group and the control group. "After consumption of the dish to what extent did you get boredwith the dish?" Scale (1-7): 1= Extremely bored, 7= Not at all bored.

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average(Sd)		N	Average(Sd)		N	Average(Sd)		N	Average(Sd)	
Bordom (low= 1/ high =7)												
Fish in white sauce	26	5.4	(1.6)	51	6	(1.1)	25	5[a]	(1.7)	47	6[a]	(1.3)
Gratinated haddock with broccoli	27	5.4	(1.8)	51	5.6	(1.8)	24	4.9	(1.7)	48	5.7	(1.5)
Haddock in curry sauce	27	5.6[b]	(1.3)	51	4.9	(2.1)	25	4.2[b]	(1.9)	49	4.4	(2.1)
Haddock in lobster sauce	26	5.5[b]	(1.7)	50	4.8	(2)	24	4.3[b]	(2.3)	45	4.1	(2)
Fish cakes	27	5.1	(1.8)	49	5.6	(1.6)	25	5.3	(1.7)	49	5.2	(1.6)
Vegetable cakes	27	5.3	(1.5)	52	6	(1.6)	25	4.7	(2)	47	5.4	(1.9)

[a] Significant difference between the omega-3 group and the control group.

[b] Significant difference between week 1 and week 4.

Appendix 14

Table 35 Three statements about preparation of the meals in week one and four for both the omega-3 group and the control group. "Please state if you agree or don't agree with these three statements (simple, quick and convenient) about preparation of the dish" Scale (1-7): 1= Completely disagree, 7= Agree completely.

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average(Sd)		N	Average(Sd)		N	Average(Sd)		N	Average(Sd)	
Simple												
Fish in white sauce	27	6.9[a]	(0.3)	49	6.4[a]	(1.6)	25	6.4	(1.7)	45	6.3	(1.6)
Gratinated haddock with broccoli	27	6.2	(1.8)	49	6.3	(1.7)	25	6.6	(1.2)	47	6.6	(1)
Haddock in curry sauce	27	6.5	(1.3)	52	6.3	(1.6)	26	6.4	(1.7)	47	6.4	(1.3)
Haddock in lobster sauce	27	5.8	(2.3)	51	5.9	(1.9)	25	6.6	(1.3)	44	6.5	(1.1)
Fish cakes	27	6.7	(1.2)	49	6.3	(1.5)	26	6.7	(1.2)	48	6.5	(1.3)
Vegetable cakes	27	6.1	(1.9)	50	6.1	(1.8)	26	6.7	(1.2)	46	6.5	(1.2)
Quick												
Fish in white sauce	27	6.9[a]	(0.4)	49	6.2[a]	(1.6)	25	6.4	(1.7)	43	6.3	(1.6)
Gratinated haddock with broccoli	27	6	(1.9)	49	6.2	(1.7)	25	6.6	(1.2)	46	6.6	(1)
Haddock in curry sauce	27	6.4	(1.2)	52	6	(1.7)	26	6.3	(1.6)	46	6.3	(1.2)
Haddock in lobster sauce	27	5.7	(2.3)	51	5.8	(1.9)	25	6.6	(1.3)	43	6.3	(1.2)
Fish cakes	27	6.6	(1.2)	48	6.3	(1.5)	26	6.7	(1.2)	47	6.5	(1.3)
Vegetable cakes	27	6.1	(1.9)	50	6.2	(1.8)	26	6.7	(1.2)	45	6.4	(1.3)
Convenient												
Fish in white sauce	27	6.9[a]	(0.3)	49	6.3[a]	(1.5)	25	6.4	(1.7)	43	6.3	(1.6)
Gratinated haddock with broccoli	27	6.1	(1.8)	49	6.3	(1.6)	25	6.6	(1.2)	46	6.6	(1)
Haddock in curry sauce	27	6.5	(1.2)	52	6.2	(1.5)	26	6.4	(1.7)	46	6.4	(1.3)
Haddock in lobster sauce	27	5.7	(2.3)	51	5.9	(1.9)	25	6.6	(1.3)	43	6.4	(1.1)
Fish cakes	27	6.7	(1.2)	48	6.3	(1.5)	26	6.7	(1.2)	47	6.5	(1.3)
Vegetable cakes	27	6	(2)	49	6.1	(1.8)	26	6.7	(1.2)	45	6.5	(1.2)

[a] Significant difference between the omega-3 group and the control group.

Appendix 15

Table 36 Rate of interest to consume the dish again after 3 days, 1 week, 2 weeks and one month in week one and four for both the omega-3 group and the control group. "Now you have recently finished consumption of the dish, how much interest do you have to consume the dish again after: Scale (1-7): 1= No interest at all, 7= Very much interest.

	Week 1				Week 4			
	Omega-3 group		Control group		Omega-3 group		Control group	
	N	Average(Sd)	N	Average(Sd)	N	Average(Sd)	N	Average(Sd)
3 days								
Fish in white sauce:	20	3.6 (2)	44	3.9 (2.1)	20	2.7[a] (1.6)	41	3.8[a] (2.3)
Gratinated haddock with broccoli	21	3.1 (2.3)	45	3.4 (2.4)	21	2.3[a] (1.6)	43	3.7[a] (2.1)
Haddock in curry sauce	21	3.2 (2)	44	2.9 (2.1)	21	2.4 (1.6)	44	2.8 (2.2)
Haddock in lobster sauce	19	3.3[b] (2.1)	43	2.6 (2)	22	1.9[b] (1.6)	41	2.6 (1.9)
Fish cakes	19	3.1 (2)	44	3 (2)	22	2.1[a] (1.3)	45	3.3[a] (2)
Vegetable cakes	17	3.1 (2)	46	4.1 (2.4)	20	2.6 (2.2)	42	3.6 (2.4)
1 week								
Fish in white sauce:	23	4.3 (2)	48	4.8 (2)	22	3.8 (2)	44	4.8 (2.1)
Gratinated haddock with broccoli	21	3.6 (2.4)	48	4.4 (2.4)	22	3.1[a] (1.8)	46	4.7[a] (2)
Haddock in curry sauce	23	4.3 (2.1)	47	3.7 (2.2)	23	3.3 (2.1)	45	3.4 (2.3)
Haddock in lobster sauce	21	4.1[b] (2.3)	47	3.6 (2.3)	23	2.6[b] (2)	42	3.2 (2.1)
Fish cakes	21	4.1 (2.1)	50	4.5 (2.2)	23	3.3[a] (1.8)	47	4.3[a] (2.1)
Vegetable cakes	21	4.1 (2.3)	49	4.9 (2.3)	20	3.1 (2.2)	42	4.1 (2.3)
2 weeks								
Fish in white sauce:	22	4.8 (1.8)	45	5.2 (1.8)	21	4.6 (2.1)	42	5.1 (2)
Gratinated haddock with broccoli	24	4.1 (2.3)	45	4.6 (2.4)	21	3.9[a] (2.1)	42	5[a] (1.9)
Haddock in curry sauce	23	4.9 (1.8)	43	3.9 (2.2)	22	3.8 (2.1)	44	3.7 (2.3)
Haddock in lobster sauce	24	4.9[a.b] (2.4)	43	3.7[a] (2.4)	22	3.1[b] (2.2)	42	3.7 (2.1)
Fish cakes	23	4.7 (2.1)	46	4.7 (2.3)	22	4 (2.1)	44	4.7 (2.1)
Vegetable cakes	20	4.5 (2.3)	47	5.2 (2.2)	21	4 (2.3)	40	4.4 (2.3)
One month								
Fish in white sauce:	21	5 (1.9)	43	5.7 (1.8)	20	4.8 (2.4)	41	5.6 (1.8)
Gratinated haddock with broccoli	22	5 (2.6)	44	5.1 (2.4)	24	4.8 (2.3)	43	5.5 (1.9)
Haddock in curry sauce	23	5.1 (1.7)	46	4.3 (2.4)	23	4.6 (2.3)	44	4.2 (2.4)
Haddock in lobster sauce	22	5 (2.4)	44	4.3 (2.4)	24	4.3 (2.4)	43	4 (2.3)
Fish cakes	22	4.9 (2.2)	45	5.1 (2.2)	23	4.7 (2.1)	43	5.2 (1.9)
Vegetable cakes	21	4.9 (2.2)	46	5.4 (2.2)	24	4.9 (2.2)	41	5 (2.3

[a] Significant difference between the omega-3 group and the control group.

[b] Significant difference between week 1 and week 4.

Appendix 16

Table 37 Probability of purchasing the dishes in week one and four for both the omega-3 group and the control group. "Would you buy this product? Scale (1-7): 1= Very unlikely, 7= Very likely.

	Week 1						Week 4					
	Omega-3 group			Control group			Omega-3 group			Control group		
	N	Average	(Sd)	N	Average	(Sd)	N	Average	(Sd)	N	Average	(Sd)
Fish in white sauce	27	4.7	(2.3)	51	5	(2)	25	4.8	(2.3)	46	5.4	(2)
Gratinated haddock with broccoli	27	4.6	(2.4)	52	5.4	(2.2)	26	4.1	(2.3)	47	4.9	(2.3)
Haddock in curry sauce	27	4.9	(2)	52	4.1	(2.3)	26	4.2	(2.4)	48	3.7	(2.2)
Haddock in lobster sauce	27	4.8	(2.4)	51	3.9	(2.4)	25	3.6	(2.6)	45	3.5	(2.2)
Fish cakes	27	4.4	(2.3)	51	5	(2.1)	26	4.7	(2.2)	49	4.9	(1.9)
Vegetable cakes	27	4.6	(2.4)	52	5.4	(2.2)	26	4.1	(2.3)	47	4.9	(2.3)

Appendix 17

Convenience seafood products enriched with omega-3

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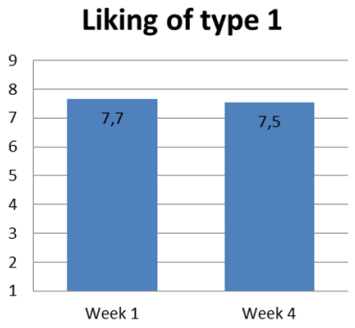

Figure 1 Liking of meal type 1 in week one and week four (on a 9-point scale; 1= Don't like at all to 9 = Like very much).

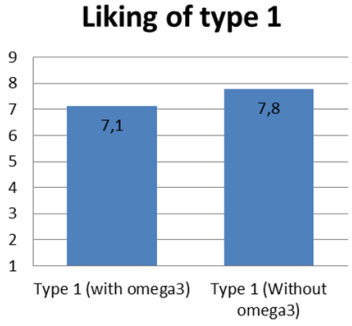

Figure 2 Liking of meal type 1 in week one for the two different groups (on a 9-point scale; 1= Don't like at all to 9 = Like very much).

Introduction

Consumers can choose from a variety of food and food supplements for their diet. The market for functional foods has been steadily growing as consumers seem to increasingly seek food products with added health value.

Many studies have shown potential benefits of consuming long-chain n-3 polyunsaturated fatty acids (LC n-3 PUFA). The main source of these fatty acids is seafood high in fat content. However, intake of LC n-3 PUFA is generally low due to low consumption of such seafood. As an alternative, omega3 has been suggested for fortification of foods.

The aim of this study is to develop oven-ready products with added positive health benefits for consumers by enrichment with omega-3 oil. The purpose is added product value and improved utilization of raw materials and by-products. The target group is mainly health oriented consumers seeking ready-to-heat products. The product development was done in co-operation with an Icelandic producer of ready-to-heat seafood meals. Consumer testing is an important part of the product development and was done as a part of a dietary intervention were the participants consumed six different types of ready meals, with and without omega-3 oil.

Materials and methods

One group of participants in the intervention study consumed six types of ready to heat meals (n = 50). A second group consumed the same six types of ready to heat meals, but enriched with omega 3 (n = 29). The participants consumed the meals six times a week for four weeks. The meals were four different fish dishes with sauce (type a-d), fish cakes (type e) and vegetables cakes (type f).

Inclusion criteria for participation was to be 50 years and older. During the in home consumption, the consumers were asked about liking of the products during consumption, how much they consumed and their experience of cooking the meal. At the end of the intervention, the participants answered questions about purchase habits and fish consumption.

Results and discussion

The intervention is on-going and will be finalized later in October. However, the results of the first part are promising. Overall, the six ready meals were well liked by the participants. The results generally indicate no significant difference ($p>0,05$) in liking of the enriched meals compared to the conventional meals. For most of the meals the liking was similar in the first and last week, as can be shown for type a (Fig. 1.) There were differences in liking between groups (with and without omega-3 oil) for two different types of meals. Figure 2 shows the differences in liking of type a in week one, the difference is significant.

Conclusion

By now we have first results that are promising and can therefor support marketing of the products.

Acknowledgement

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