

Creating value

Project year 2013



32 examples of useful research



Norwegian Institute of Food, Fisheries and Aquaculture



Creating value with applied research



As the global population increases so does the demand for food that is safe, healthy and of high quality. With its rich fisheries and aquaculture industry, Norway plays an important role in an international food security perspective. The Norwegian agriculture and food industries are contributing with the production of high quality food. The Norwegian food production is knowledge-based and in the future this will be even more important.

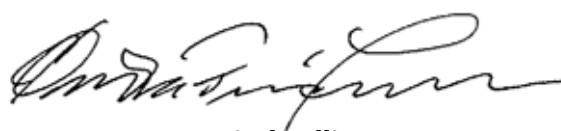
Nofima contributes by providing research-based knowledge and advice to the food value chain, regardless of the origin of raw materials; fisheries, aquaculture, or agriculture. Our main focus is to help stakeholders in the food industry to develop solutions that increase profitability in both a short and long-term perspective. Through the development of a new business plan, we hope that in 2014 our clients will perceive us as even more industry oriented.

In order to develop profitable solutions we use a wide range of tools. Long-term, applied and industry-oriented research projects of several years' duration provide the foundation for our competence. The research builds the basis for the advice we give to each producer or business. An important part of our work is to ensure that the projects are relevant to industry stakeholders, implemented in a good way and not least that the results are of high quality and put to use. In *Creating Value*, we provide examples of this.

An important factor is the financing of the projects. I would therefore like to emphasize the importance of the funding agencies as partners in industry-oriented research. Whether it's the Research Council of Norway, the Norwegian Seafood Research Fund, the Foundation for Research Levy on Agricultural Products, Innovation Norway or others, their financial support for industry-oriented research and our focus on value creation are decisive. Of course, that is also the case when the companies themselves fund the research and development in full or in part.

We demonstrate this by presenting 32 new examples of applied research that have proven to be useful. We cast the net wide and present research results from the fisheries, aquaculture, food and feed industries. The projects have a broad scientific approach and are based on the forefront of our competence. Our capable employees keep going in order to deliver relevant and useful knowledge to increase value creation in the industries.

We wish you an enjoyable read!



Øyvind Fylling-Jensen
Managing Director



NATIONAL FACILITY FOR MARINE BIOPROCESSING – NAMAB

Bioprocessing is the use of biological components, such as living cells and enzymes, in the processing of various raw materials to other products, such as proteins and oils. Marine bioprocessing is based on raw materials from the sea, mostly by-products from fish, sea urchins or kelp.

Marine biotechnology and bioprocessing have for many years been areas of priority for academic institutions and companies. At Kaldfjord near Tromsø, Nofima has established a “mini factory” where high technology companies can receive help to transfer good research results from the laboratories and produce advanced products on a larger scale.

For more information, please contact NAMAB Manager Rasmus Karstad, tel. +47 77 62 92 10

Nofima's mission

Our mission is outstanding research, development and innovation for the food of tomorrow.

This means that

- our research shall be relevant and of high quality and utility value
- we shall be innovative, responsible, committed and inclusive
- we shall think carrying out, competence development and implementation

Our strategy is based on the vision "Creating value together" – and in collaboration with our clients we deliver internationally recognized research and solutions that provide a competitive edge throughout the entire value chain.



32 examples of useful research

Keeps salmon fresh for 20 days	7
Big losses on variable quality	8
Measure quality, save money	9
Salmon that don't tempt lice.....	10
Nutrition in ready-to-eat meals.....	11
Removing Listeria with steam	12
Packaging method decides colour.....	13
New aquaculture revolution?	14
Better measurement of shelf life.....	15
Wanting hen back on the menu.....	16
Proteins influence pellet strength	17
22% extra for line caught.....	18
Hunting for the perfect berry	19
Better control of environment.....	20
Big spin-offs from aquaculture	21
New method kills pathogens	22
Whole grain diets combat bacteria.....	23
Studying fish health via genes	24
Stops sexual maturation in cod.....	25
New book about live storage.....	26
Controlling fish oil quality.....	27
Keeping a lid on cured sausage.....	28
A taste of seafood souvenirs.....	29
Which food fills you up?	30
Breeding fearless farmed fish	31
Resisting lice is top priority.....	32
Beta-glucan and immune defence	33
Data that provides direction	34
Taste interaction in meals.....	35
Seeking optimal salmon diet.....	36
Purse seine fleet can add value.....	37
Fishing luck in a tube.....	38
Facts and figures	39

Keeps salmon fresh for 20 days

Superfresh is the name of the packaging method that enables salmon to stay fresh for up to 20 days. Several years' research is behind this.



PHOTO: KJELL J. MEROK © NOFIMA

Senior Research Scientist Marit Kvalvåg shows salmon in Superfresh packaging. The secret lies in the cushion the fish is placed on.

Briefly, Superfresh is a form of packaging in which salmon is placed on a cushion (CO₂ emitter) consisting of baking powder and citric acid, among other things. The air is then removed from the pack and gas is added before it is sealed. This packaging method is called Modified Atmosphere Packaging (MAP). Superfresh enables the salmon to stay fresh for up to 20 days at 1 °C or 10–12 days at 4 °C.

Initially, an emitter has been specially designed for cod and salmon fillet, but the same method could eventually be used for other types of fish and also for meat.

“After the pack is sealed, the cushion develops CO₂ gas and also has absorbent properties. This CO₂ emitter has been adapted for the product, so that it does not change the pH value of the fish, and sensory tests have shown that the fish often has a better quality than comparable packaging methods,” says Senior Research Scientist Marit Kvalvåg Pettersen at Nofima. She has been responsible for the research over the last few years.

CONSUMER PACKAGING: The consumer packaging is now ready for the market and at a later stage transport packs will also be developed. As well as extending shelf life, this packaging method has major transportation advantages; it requires less volume and may be transported together with other food.

“We are very excited about how it will be received. We envisage two main groups that could benefit from this packaging method for fresh products - the industry that prepares and serves food (the HORECA segment) and the consumer market,” says Jan Endre Vartdal, Director of Vartdal Plastindustri.

TAILORED TO THE SIZE OF THE FISH: There are several factors that make Superfresh a true innovation. In addition to shelf life, the packaging is suited to both the type and size of the fish to give the optimum quantity of CO₂ gas.



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Big losses on variable quality

The export value of Norwegian white fish could be significantly higher with better raw material quality.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Quality can make the difference between profitable and unprofitable production.

Scientists Morten Heide and Edgar Henriksen interviewed industrial actors and exporters in the white fish industry, and compared the results with earlier work and official statistics. The conclusion is that despite a good supply from a stable cod stock, the fish that is landed is of extremely variable quality. This leads to reduced earnings.

INDUSTRY MUST TAKE RESPONSIBILITY: Large amounts of the raw material are poorly bled, have gaping and have other damage from rough handling. These quality errors result in higher production costs, lower prices for the end products and a poor reputation. The gear types gillnet and Danish seine score lowest in relation to quality of raw material.

There are complex reasons why such a big proportion of the coastal fleet's catches are landed with reduced quality. But it is primarily the fishermen and the industry itself that can raise the quality by improved handling and choice of gear types.

"There is a need for a good dialogue between the fisherman and buyer and it is clear that individual actors

have a responsibility and an opportunity to improve the quality to avoid big loss of value," says Heide.

QUALITY MAKES THE DIFFERENCE: In the market for fresh fish, it is normally one and a half to twice the price for high quality cod compared to the price for industrial raw material. The production costs for poor quality fish are also higher.

"Our calculations show that quality can make the difference between profitable and unprofitable production."

Fish products of high quality can also further increase their value. In order to achieve a better price in the high quality market, good communication with the fishermen, understanding of the market and a long-term approach are important. It is also necessary to develop more market segments with high willingness to pay, and to secure a continuous flow of raw materials and products over time.



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Measure quality, save money

Sensors adapted for use in the food industry make automatic and precise sorting of raw materials possible, and improves efficiency.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Nofima Senior Research Scientist Jens Petter Wold scans a block of cheese in an NIR scanner in the laboratory.

Novel sensors and automation is the name of a project in which the main objective is to develop sensor technology that can help food companies to optimize utilisation of raw materials, improve logistics, increase profitability and minimize wastage.

The research in this project is divided into two parts:

1. Further development of existing sensor technology in order to exploit what researchers have already made in the best possible manner.
2. Development of completely new sensor technology, small and cheap sensors, so the food industry (and other industries) to a greater extent can make use of this technology in order to become more hi-tech and automatically quality controlled.

“In the long term this will strengthen competitiveness and safeguard market channels,” says Nofima Senior Research Scientist and Project Manager, Jens Petter Wold.

PRECISE MEASUREMENTS: One example from the project is the development of a system to automatically sort fish by species, size and exterior qualities.

“We are using a camera and a laser line that scans the fish and provides feedback to a computer about how much the fish weighs, exterior quality and which species it is,” says Wold.

Such a system provides opportunities for far more precise and detailed sorting than is the case with the current system, and consequently better utilisation of the raw material.

Another example is the development of automated and more precise measurements of fat and fat composition in, for instance, milk. This utilizes Fourier Transform Infrared (FTIR) spectroscopy.

“This will give the producer detailed quality information about the milk and the possibility of optimal use during further processing,” concludes Wold.



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Salmon that don't tempt lice

Purposeful selective breeding makes it possible to develop a salmon with increased resistance to lice.



PHOTO: BJARNE GJERDE © NOFIMA

Counting salmon lice at Nofima.

There are currently two methods to combat salmon lice: delousing with medications and biological delousing. However, both methods offer problems. Delousing with medications is widespread, but the lice develop resistance to this. The challenge with biological delousing – using other species wrasse to eat the lice – is a limited supply of wild wrasse. Commercial production of wrasse is therefore a priority area. A vaccine against lice is at the development stage.

SELECTIVE BREEDING CAN SOLVE THE PROBLEM: “Selective breeding is another method. Our trial results indicate that this may be the way to solve the problems with lice. Some salmon families are less likely to get lice, just as some people are less likely to be bitten by mosquitoes,” says Senior Scientist Bjarne Gjerde.

Consequently, the salmon's resistance to lice may be increased by using fish from families with high resistance to lice as broodstock for new generations of farmed salmon.

Theoretical calculations show that by selecting only for increased resistance to lice, we can expect progress of 24 % per generation, and the cumulative effect of 75 % over five generations. In practice, the progress will be less than this as selections must also be performed for other traits.

NEED LONG-TERM APPROACH: Selective breeding can be an important measure to combat the problems with salmon lice, but it will take a few salmon generations before the effect is noticeable for the individual farmer.

Breeding companies that select for increased resistance to lice will currently have higher costs than those that only select for traits that provide direct returns.

“I believe we will be better served if the State either instructs all breeding companies to make a selection for increased resistance to lice or subsidises those that choose to do so on their own initiative,” concludes Gjerde.



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Nutrition in ready-to-eat meals

A comparison of four ready-to-eat dinners to four equivalent home-cooked dinners shows that they are equally healthy.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Fjordland's meatballs.

A lot has been said about the content and nutrition in ready-to-eat dinners. Many people have formed an opinion that there is insufficient nutrition in ready-to-eat food and consequently we should not eat it too often. This analysis has a different conclusion. A ready-to-eat meal can have the same nutritional content as a home-cooked meal using the same ingredients.

The National Institute of Nutrition and Seafood Research (NIFES) has analysed four ready-to-eat dinner meals from Fjordland AS and found high values of various nutrients. An assessment of these levels of nutrients, performed by Nofima, concludes that the nutrient content in these dishes is comparable with the equivalent home-cooked food.

The dishes that were analysed for the content of energy-giving nutrients, vitamins and minerals were: boiled salmon with herb sauce, potatoes and baby carrots; roast pork with sauerkraut and potatoes; meat balls with mushy peas and potatoes; beef stroganoff and rice.

The documentation of health effects from food components is complex, and there are many factors that need to be considered. But one of the test parameters is the level of nutrients in the food on the plate just before it is eaten. The storage and heating carried out at the laboratory was equivalent to what a consumer would be expected to do at home with a sous vide product from Fjordland.

The levels of the nutrients analysed for Fjordland's dinner products are comparable with equivalent nutritional values in the food database, i.e. the levels calculated for an equivalent home-cooked dinner. The dinner products in this report contain the nutrients one would expect from a normal dinner. The analysed dishes from Fjordland can form part of a healthy and varied diet on the same level as equivalent home-cooked dinners.



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Removing Listeria with steam

Rapid heating of the surface with steam at 100 °C can kill unwanted bacteria on fish products.



PHOTO: JAN THOMAS ROSNES © NOFIMA

Torstein Skåra places a sample in the steam chamber of the test rig. It is closed and steam is injected from above at given time intervals.

Listeria monocytogenes is a pathogenic bacterium that creates problems for the seafood industry by contaminating the surface of products with otherwise good microbiological status. Chilled products with extended shelf life, such as smoked fish or processed fish products, are particularly vulnerable as the bacteria grow at refrigeration temperature.

“The main objective of my PhD project has therefore been to find a method that can eliminate possible contamination by *Listeria* from the products just before packing,” says Nofima Scientist Torstein Skåra.

SURFACE TEAM PASTEURISATION: A specially designed test rig built at the University of Bristol was purchased for the experiments. The *Listeria* bacteria are then eliminated using steam pasteurisation for a few seconds. The unique feature of surface steam pasteurisation is that it only affects the outermost part of the surface and, consequently, has a minimal impact on appearance or nutritional status.

Skåra performed a number of systematic experiments with various contamination levels of bacteria. This made it possible to quantify steam killing of *Listeria* on the surfaces of the products. He used spectroscopic technology to determine the effect of the heat treatment on the product. Models were used to compare steam pasteurisation with water bath treatment.

IMPROVED FOOD SAFETY WITH CORRECT USE: Skåra has studied the choice of various model organisms and compared the growth of *Listeria monocytogenes* strains isolated from the fish processing industry. These findings are important when using mathematical models to see how various organisms grow and how quickly they die. This work resulted in a new method for determining how efficiently steam kills *Listeria*.

“With correct use of this technology, the food safety of seafood products with extended shelf life may be improved considerably,” says Skåra.



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MORE INFO:



Packaging method decides colour

Meat that has been in contact with oxygen before cooking poses a food safety risk as the colour may not be used as an indicator for cooking.



PHOTO: KJELL J. MEROK © NOFIMA

Hamburgers made of ground beef packaged in oxygen-rich atmosphere look thoroughly cooked before they actually are.

In order to be safe to eat, raw products made from ground beef must be cooked until they are at least 71 °C in the centre. However, it can be difficult for consumers to measure the temperature during cooking.

Meat packaged in oxygen-rich atmosphere is widespread in Sweden, Denmark and other European countries. But in Norway this method is relatively new. The advantage of an oxygen-rich atmosphere is that the first few days after packaging, the meat has a redder colour than with other packaging methods. A disadvantage is that the colour in the centre of a hamburger cannot be used to decide whether it is thoroughly cooked or not.

PEOPLE USE COLOUR AS AN INDICATOR FOR COOKING: In a research project led by Nofima, Norwegian consumers were asked whether they make hamburgers at home from ground beef or whole muscle meat and how they judge whether a hamburger is thoroughly

cooked. Laboratory tests were also carried out to study the connection between killing dangerous E. coli bacteria and colour change during cooking. The trials showed that it is difficult to measure temperature during cooking. No suitable thermometers are on the market.

“Hamburgers should be cooked until they are at least 71 °C in the centre in order to kill bacteria, then they are cooked through and safe to eat,» says Nofima Research Scientist Solveig Langsrud.

For ground beef that is vacuum-packaged or packaged in an oxygen-free gas mix, a change in colour from red or pink to brown is a good indication of whether the hamburger has been cooked enough to kill bacteria. This is not the case for oxygen-packaged meat.

“Meat that has been packaged in an oxygen-rich atmosphere already looks cooked through when it reaches 60 °C,» says Nofima Research Scientist Oddvin Sørheim.



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MORE INFO:
Article about gas packaging of meat



New aquaculture revolution?

A lot needs to happen to threaten the hegemony of the net-based production concept in salmon farming, a report from Nofima shows.



PHOTO: REIDUN LILLEHOLT KRAUGERUD © NOFIMA

Can the Norwegian aquaculture model be threatened by land-based systems in countries with low production costs?

On commission from the Ministry of Fisheries and Coastal Affairs, the scientists have evaluated if new operational concepts in aquaculture can threaten Norway's position as an aquaculture nation.

The scientists have evaluated land-based recirculating systems both in Norway and in countries with low production costs, offshore sea cages and closed-containment systems in both exposed and sheltered locations.

"We see that land-based or closed sea-based systems, often using recirculating technology, are being built in Denmark, North America, Scotland and China. Land-based or closed systems will involve much higher investment costs, but some of this disadvantage is expected to be offset by lower operating costs. However, there is a long way to go before closed constructions will be as economical as today's net-based solutions," says Scientist Audun Iversen.

COSTS: The average production cost of the current net-based aquaculture is NOK 24 per kilo of salmon

produced. The costs for the other concepts are far more uncertain, so the scientists have developed an analytical model to take the uncertainty into account.

"There are much higher costs in the closed or semi-closed concepts, at least NOK 5-10 above today's net-based concept," says Iversen.

Major policy changes, such as stricter environmental requirements, may change this picture. The scientists also envisage that technological paradigm shifts, which give major changes in the cost level, can impact on the probability of the success of the various technologies. In the long term, more efficient land-based aquaculture can come close to the net-based costs. Land-based aquaculture in low-cost countries may be a future threat.

The scientists believe that we will see more examples of combination models, where more of the salmon's growth (e.g. up to 1 kg) occurs in land or sea-based closed-containment systems.



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Better measurement of shelf life

A new method makes it possible to establish the shelf life of fish without knowing in advance how and for how long it has been stored.

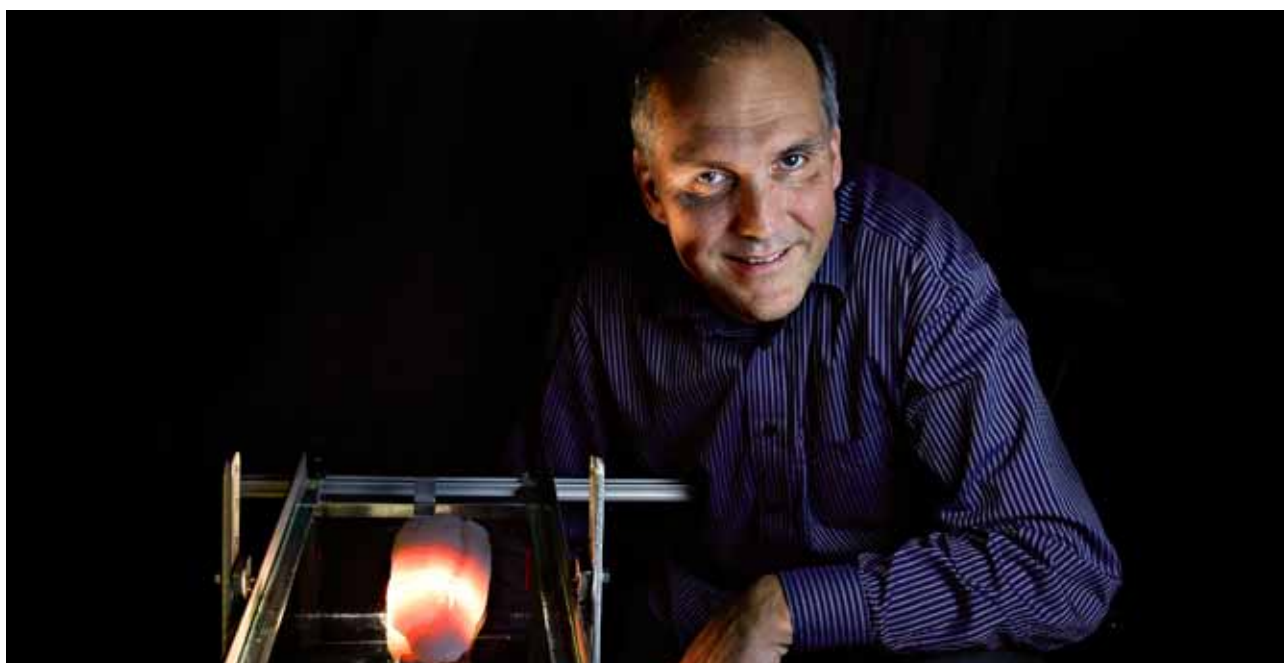


PHOTO: AUDUN IVERSEN © NOFIMA

Senior Scientist Karsten Heia uses light measurements (spectroscopy) to determine the remaining shelf life of fish with unknown background.

Fishmongers and fish shops focus on high quality of the food they sell, and in order to be able to set a best-before date they need to know how long the fish has been stored on ice or in refrigeration when they receive it.

Stipulating shelf life involves several elements of uncertainty, including how the fish is handled in the boat, on land and during transport. For instance, leaving the fish on the deck for several hours before chilling can reduce the shelf life by several days.

LIGHT PROVIDES ANSWERS: Nofima has used light measurements (spectroscopy) to determine the remaining shelf life of cod. By sending light through the cod fillet, the scientists can see how much light is absorbed at different wavelengths.

When the fish is exposed to oxygen, the iron bearing proteins (heme proteins) in the fish muscle are oxidized. In other words, the iron bonds with the oxygen in a chemical reaction. The longer the cod is stored, the more oxidized it becomes. Oxidation leads to changes in how

much light is absorbed when the scientists send light at different wavelengths through the fish.

“By measuring oxidation changes in heme proteins, we can find the remaining shelf life of fish and whether the fish has been frozen and defrosted,” says Senior Scientist Karsten Heia.

NEW TECHNOLOGY: The quality and shelf life of fish is equally important for consumers, retailers, processors and buyers, and is decisive for price. The next step is to develop an instrument that makes it easy to use this method.

“A handheld device that fish shop staff could easily use to measure the remaining shelf life of the fish would be extremely useful and ensure better quality,” says Heia.

This method has previously been successfully tested on salmon. The scientists are planning to expand the method so it can also be used on saithe, halibut, monkfish and other species.



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Wanting hen back on the menu

Around 2.3 million edible Norwegian laying hens are disposed of annually. Pre-cooked hens in their own juices can reduce this food waste.



PHOTO: KJELL J. MEROK © NOFIMA

Sale of pre-cooked hens has several benefits. The farmers make savings, it is good and affordable food, and food waste is reduced.

The Armed Forces, egg producer Toten Eggpakkeri, grocery wholesaler Norgesgruppen and Nofima are now testing out hen fricassee as a dinner for soldiers. The fricassee is made from organic hens that have served their purpose on the egg laying front.

The hens are slaughtered and processed at Gårdsand in Vestfold. The hens are then vacuum packed, simmer at 85 °C for 10 hours and are then frozen. The Armed Forces' canteen receives the frozen hen bags. After de-frosting, the hen meat is picked off the bones and put in the cooking pot.

A RARE SIGHT: Hens are seldom served on Norwegian dinner tables. The main reason is that preparation takes too long. Consequently, the scientists at Nofima asked the question: How can hens be made more easily accessible?

"In the Armed Forces, we have a goal of 15 percent organic food and in that case organic hens will be a good contribution. Far too much food is wasted and we

want to play a part in getting the hen back as a food resource," says Pål H. Stenberg, Lieutenant Commander and Coordinator of Garrison & Combat feeding in the Armed Forces.

WIN-WIN SITUATION: In the first phase, in addition to the Armed Forces, large-scale caterers and hospitals are viewed as potential customers for the pre-cooked hens in their own juices. With improvements, the partners also envisage that sale to the grocery industry may also be realistic.

The farmers currently pay around NOK 5 for each hen they dispose of so, even if the farmers do not get paid for the hens that are used for food, it will still be financially beneficial for them. If all 2.3 million former laying hens that are currently disposed of are used for food, the farmers will make a combined saving of NOK 11.5 million. This is in addition to the environmental savings obtained through reduced food wastage.



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Proteins influence pellet strength

The physical and chemical properties of fishmeal influence both the production of fish feed and the physical feed quality.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

The physical and chemical properties of fishmeal influence both the production of fish feed and the physical feed quality.

High physical feed quality is important for the salmon farmers. This new knowledge about the complexity of the protein sources can help the feed producers to achieve better control of their production process and the quality of the feed.

Fishmeal is used extensively in fish feed and is purchased based on a limited number of specifications. Nofima has now demonstrated that these specifications are inadequate in order to predict the physical quality of the fish feed. This new knowledge may also be applied to plant and other animal-based feed raw materials.

EXTRUSION TECHNOLOGY AND BREAD BAKING: Salmon feed is currently produced by extrusion technology – a rapid kneading and cooking process at high temperature, similar to preparing dough in your kitchen to bake bread. This process results in a series of physical and chemical changes in the feed raw materials. The quality of the

fish feed may be controlled and improved by adding starch and other binding agents, but the proteins in the fishmeal will also contribute to the physical quality of the feed.

MAJOR STRESS ON FEED: The physical quality of fish feed has become more important in recent years because the feeding system blows the feed through long pipes from storage bins to the fish cages. This exposes the feed to mechanical stress and may lead to crushing. Crushing of the feed pellets is a problem since the fish cannot eat small particles or dust, and dust clogs up the feeding system.

“We have documented for the first time that variation in the physical and chemical properties of fishmeal influences both the extrusion process and the physical quality of the feed,” says Project Manager and Senior Scientist Tor Andreas Samuelsen at Nofima.



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22% extra for line caught

British customers are willing to pay up to 22% extra for a pack of frozen cod or haddock when the pack is labelled “line caught”.



PHOTO: EDGAR HENRIKSEN © NOFIMA

British customers are willing to pay more for fish if it is labelled “line caught” and “Icelandic”.

The study shows that the label “Icelandic” also provides a price premium of five per cent and that there are great differences in prices between British supermarket chains.

“The fact that chains choose to label products as line caught is probably because this method is perceived as more gentle on the seabed and thus well in line with the chains’ efforts to act responsibly,” says Senior Scientist Geir Sogn-Grundvåg.

He believes that the fishing industry, in a situation with heavy pressure on prices as a result of record cod catches and reduced purchasing power in the largest whitefish markets, has a good opportunity to improve its finances by offering more differentiated products.

100 PRODUCTS MONITORED: In the autumn of 2010 Nofima started recording the prices of almost 100 different fillet products of cod, haddock and Alaska pollock in seven British supermarkets. A so-called hedonic price analysis was employed, which enables one to uncover the effect of each individual product attribute on price.

CHOICE OF SUPERMARKET: The greatest pricing deviations are linked to the supermarkets’ own brands.

Marks & Spencer leads with a price premium of 49%, followed by Coop with 32% and Waitrose with a 30% price premium, while Tesco and Lidl have price premiums of -23 and -25 per cent respectively.

In the frozen whitefish fillet sector there are only two manufacturer brands, Birds Eye and Young’s. Birds Eye achieves a significant price premium of up to 46%, while Young’s achieves a premium of 21%. It is also worth noting that Alaska pollock fillets are far cheaper than cod and haddock fillets.

“The significant price differences may be useful information for Norwegian exporters who are considering which supermarket chains they should offer their products,” says Sogn-Grundvåg.



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MORE INFO:
 Read the article



Hunting for the perfect berry

About 100 varieties of strawberry and raspberry have been tested to find those best suited for making jam. Only a few made the grade.



PHOTO: KJELL J. MEROK © NOFIMA

Plant breeders, fruit growers, jam producers and scientists are collaborating to find the perfect berry varieties.

The most promising varieties include the raspberries ‘Glen Fyne’ and ‘Cascade Delight’ and the strawberry ‘Saga’.

As well as thriving in Norwegian weather conditions, the varieties must provide good crops, maintain high quality and be suitable for processing.

The most important qualities of jams are colour, taste, aroma and nutrient content. Making jams from 100 varieties of berries, and then analysing them for both sensory qualities and chemical composition, is a large and demanding job. All the jam producers used the same recipe, stored the jams for up to six months and assessed taste and colour of the jams.

Research Scientists Kjersti Aaby and Berit Karoline Martinsen and PhD student Sebastian Mazur (Bioforsk) analyzed the jams for compounds that contribute to colour and healthiness. In this context, the anthocyanins play a very important role, providing both the red colour and promising health-beneficial properties.

SOURCE OF PURPLE: The scientists analysed how the anthocyanins, and thereby colour, managed when the berries were homogenized and heated and the jam was stored. They also investigated how the anthocyanins were affected by other constituents in the berries.

“For raspberries, there appears to be a correlation between the amount of anthocyanins in the berries and the colour stability of the jam. The more anthocyanins in the berries, the more stable the colour was. For strawberries, finding correlations is harder, but it appears that jams made from strawberries containing high concentrations of vitamin C have less stable colour,” says Kjersti Aaby.

The scientists have also studied the consequence of making jams from berries at various stages of ripeness. It was found that the colour changed most during storage of jams made from the least ripe berries.

“So, make jam from well-ripened berries,” advises Aaby.



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MORE
INFO:



Better control of environment

Closed containment systems provide better control of the fish's environment as well as opportunities for better growth, health and welfare.



PHOTO: © NOFIMA

Increased control in closed systems leads to fewer stress factors, and a controllable water intake makes it easier to avoid salmon lice.

Closed containment systems for aquaculture have a closed or virtually closed physical barrier between the production water and the surrounding environment. These systems can have several advantages, but the advantage of better control possibilities has not been exploited sufficiently to date.

"We have studied what is needed to give salmon of up to 1 kg (post-smolt) good growth conditions in closed systems. Low salinity and exercise are key factors for success, says Nofima Senior Scientist Bendik Fyhn Terjesen.

BENEFIT FROM LESS SALT AND MORE EXERCISE: The scientists carried out a pilot study of smolts weighing 70 g. Each of 12 tanks contained 600 smolts. There were four tanks each with salinity of 12 parts per thousand (‰), 22‰ and 32‰. Within each salinity group, the smolts in two tanks were subjected to physical training (high water velocity), while the other smolts were not (low water velocity). The conditions for the fish in all the

tanks were otherwise identical (same feed, light and temperature).

The trial showed that post-smolts grew slower and mortality was higher if the salinity of the water was high. The salinity of 12‰ gave the best results. Physical exercise had a positive effect on both heart size and growth rate. The trial also showed that recirculating aquaculture systems were most effective at the lowest salinity, 12‰. The trial will now be repeated on a larger scale with realistic industrial conditions.

The disadvantage of current closed systems is high production costs. Knowledge about good environmental and welfare conditions in closed systems will enable the systems to be built and operated in a more purposeful manner.

"A possible solution, providing environmental and cost savings, is to keep post-smolts in closed systems up to 1 kg and then move them to traditional cages. This new production platform may be coined 'combination line'," says Terjesen.



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Big spin-offs from aquaculture

Increasingly more employment linked to the aquaculture industry is found in companies that supply equipment or services to the industry.



PHOTO: FRANK GREGERSEN © NOFIMA

The fish farmers will gladly buy locally providing they can find the necessary competence.

This emerges in a report by Nofima on commission for the Troms County Council.

The most visible part of the aquaculture industry is the production of food. A medium-sized marine fish farm in Troms produces just as much “meat” annually as the entire agriculture industry in Troms and Finnmark combined – around 5000 tonnes. The aquaculture industry in Troms constitutes 635 man-labour years, in the production of juveniles, fish for consumption, processing plants and well boat transport.

The less visible part is all the activity that takes place among the industry’s many suppliers. Specialist suppliers now handle several of the tasks previously done by fish farmers, such as maintaining the net cages, mooring, installing the fish farms and diving services. Feed and smolt are both delivered by boat to the fish farm and the harvested fish is collected at the fish farms. This means that more of the employment is being transferred from the primary value chain to the suppliers. New specialist services are also springing up, including in relation to fish

health, monitoring, reporting, environmental analyses and certification.

PREFER TO BUY LOCALLY: Fish farmers in Troms spend more than NOK 3 billion per annum on goods and services, of which NOK 2.5 billion is spent in Northern Norway.

“Fish farmers place emphasis on buying locally, providing they find competent actors,” say the scientists, Audun Iversen, Otto Andreassen and Roy Robertsen.

Aquaculture is now the largest private sector industry in some small municipalities in Troms, accounting for over 10% of employment.

Many suppliers arise from similar activity, such as fishing equipment producers or the shipbuilding industry also focusing on aquaculture.

“Along with increased industrialisation and professionalization, we also see that many of the wider economic benefits are concentrated in municipalities with strong business sectors.”



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 Troms County Council

New method kills pathogens

A new processing method for dead fish from the aquaculture industry leads to reduced energy consumption and products with more uses.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

This is the end product of the new method and may be used as biogas and fertilizer, as well as a feed for dog teams.

This method can benefit the entire aquaculture industry. In 2012, approximately 1,2 million tonnes of farmed salmon were produced in Norway. Around 5% or 60,000–80,000 tonnes of the fish die in the cages. The fish are collected daily and preserved on site by grinding and mixing them with formic acid. The fish may have died of various causes, including disease.

Dead fish basically have the same nutritional content as harvested fish, but the risk of the fish containing various pathogens is far greater. Pursuant to current regulations, material from dead fish must be treated with high pressure sterilisation, which is highly energy-intensive and harmful to the products.

“We have carried out several projects to map how much heat is needed to provide adequate killing of relevant pathogens in fish preserved in formic acid,” says

Senior Scientist Halvor Nygaard from Biolab at Nofima.

Salmonella and Clostridium perfringens spores were among the pathogenic bacteria studied. The IPN virus, which is the most heat-resistant among known pathogens in fish, has also been investigated. New knowledge about the heat resistance of the IPN virus has made it possible to establish process requirements that ensure safe products.

The new processing method is based on formic acid treatment at pH 4 stored for 24 hours followed by heat treatment at 85 °C for 25 minutes. This method has been tested in industry scale at Scanbio in Bjugn, and is now about to be approved by the EU, after gaining a positive risk assessment from the European Food Safety Authority (EFSA).



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MORE INFO:
Read the report



Whole grain diets combat bacteria

More coarsely ground feed for chickens and feeding at specified times can reduce the risk of bacterial infection.



PHOTO: GRETHE RINGDAL, ANIMALIA

Once *Campylobacter jejuni* comes into the chicken house, it can spread to the entire flock within a few days.

Campylobacter jejuni is the most common pathogenic bacteria from chicken and is the main cause of bacterial diarrhoea in western countries.

The bacteria are found in the chicken intestine and can be transferred to the meat during slaughtering. It does not reduce the chicken's health but, as the bacteria survives well in non-processed poultry products, is a major problem for the poultry industry.

"Strict hygiene barriers in the traffic of people and equipment are an important tool, but we also need strategies to reduce or eliminate the bacteria from the chickens once they are infected," says Research Scientist Birgitte Moen.

Along with other food safety scientists, she has investigated whether feed can make chickens more resistant to *C. jejuni*. More coarsely ground feed, the addition of certain organic acids and feeding at specified times all reduce the risk of infection.

USING THE CHICKEN'S OWN BARRIERS: Chickens have several natural barriers against bacteria in the upper part of their digestive tracts. Here we find the crop, with its lactic acid bacteria, and gizzard, which performs the chewing function. The feed goes straight through the oesophagus and into the crop, where it is moistened. The feed is then "chewed" down to a suitable size in the gizzard. Chickens that eat whole grains get a larger and better developed gizzard, providing better protection against bacterial infection.

The barrier function of the crop can be improved by adding organic acids to the feed and by giving the chickens access to feed at specific times of the day, instead of continuous access.

"Our trials have shown that when both formic acid and potassium sorbate are added to the feed, the incidence of *C. jejuni* in the chicken intestine is reduced. It is the combination that gives a very positive effect. Adding only one of the organic acids has very little effect," Birgitte Moen concludes.



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MORE INFO:



Studying fish health via genes

Scientists at Nofima are using a recently developed genomic tool to identify why some salmon are more resistant to lice than others.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Senior Scientist Aleksei Krasnov uses this microarray scanner to measure the expression of thousands of genes at the same time.

“The methods are based on microarrays that enable us to study expression of thousands of genes at the same time,” says Senior Scientist Aleksei Krasnov. “The aim of this research is to find what the genes can tell us about fish health and to identify differences in the gene expression of healthy versus sick fish.”

HAVE MAPPED GENETIC RESISTANCE TO SALMON LICE:

Salmon lice is currently dealt with largely by treating fish with medications. However, there is a strong desire to use biological methods (e.g. wrasse) or breeding of fish with increased resistance to lice.

“We didn’t know why some fish were more or less resistant to lice before we performed the analyses of the gene impressions,” says Krasnov.

He now has a better understanding of why some salmon are more easily infected by lice than others. The scientists conducted challenge experiments to identify the genes that control resistance to salmon lice.

Nofima has established a lice infection model at Tromsø Aquaculture Research Station, which was used in the experiment. The fish were divided into three groups. One group received feed containing the sex hormone testosterone, the second received estrogen and the third was a control group. When the feeding ended, the fish were pooled and infected.

“It was proven that salmon fed estrogen were far more resistant to lice, and analyses of the gene expressions showed specifically which genes were important to increase this resistance,” says Krasnov.

However, there are many reasons, both ethical and commercial, why giving fish estrogen to increase resistance will never be an option, including the fact that estrogen leads to earlier onset of sexual maturation.

Sex hormones were used only as a tool to identify the genes that changed expression, and the changes in gene expression indicated which genes contribute to increasing resistance to salmon lice.



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Stops sexual maturation in cod

Early onset of sexual maturity is a great problem in cod aquaculture due to negative effects on growth, feed utilisation and health.



Adrijana Skugor moves on to studying early onset of sexual maturity in salmon.

Farmed cod that escape can also affect the genes of wild fish. Nofima scientist Adrijana Skugor has examined biological mechanisms that control development of the sex organs in cod.

She has studied both individual genes and the whole cod genome to obtain more knowledge about how the germ cells of the embryo develop into eggs and sperm.

A “DEAD END” SHOWS THE WAY: Skugor made use of the knowledge she gained while studying zebrafish. In zebrafish, the dead end gene (DnD) is necessary for development of germ cells, and she has now studied the significance of this gene in Atlantic cod.

She injected cod embryos with a molecule that blocks DnD and found that inactivation of the gene stops sexual maturation in cod too. Skugor used micro array screening to study the effects of DnD inactivation in a wider context.

TRANSFERRING KNOWLEDGE TO SALMON RESEARCH: “We now know that DnD is a good candidate for inhibi-

tion of germ cell development,” says Skugor. “But the method used is costly and complicated and cannot be used commercially. It has however been important in the work of developing tools that make it easier to obtain knowledge about how the cells develop.”

As a commercial method, it may be better to block the dead end proteins in the mother fish, rather than blocking the dead end gene in the embryo. Skugor will establish this strategy in salmon, in a project financed by the Norwegian Seafood Research Fund, as early sexual maturation is also a major problem in salmon farming. In this way, much of what has been learned from studying cod may be brought into the work on salmon, in the same way as Skugor previously made use of knowledge from zebrafish studies.

“Skugor’s research has improved our knowledge about the differentiation of germ cells and about the general embryonic development of Atlantic cod”, says supervisor and Senior Scientist Øivind Andersen at Nofima.



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New book about live storage

A new handbook leads the way for everyone planning to start live storage or capture-based aquaculture of cod.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Fish hotel: The live storage of wild fish in sea cages can provide better quality and opportunities for more strategic sale of fish.

The book is based on decades of research and outlines the equipment and procedures required to succeed with this new form of capture.

It provides good advice on topics including the most gentle capture methods for cod, how to keep the fish alive, design of fishing boats, transfer to sea cages and feed enhancement.

“In addition to research, much of the knowledge about capture-based aquaculture is based on trial and error. When new vessels have expressed their interest in this fishery and inexperienced fishermen have started without any form of training, the same mistakes have unfortunately been repeated far too often. The objective of this book is to prevent old mistakes from being repeated and to raise the interest in this method that provides the highest quality of cod in the world,” say the two authors, Kjell Midling and Bjørnar Isaksen.

The authors are scientists at Nofima and the Institute of Marine Research respectively.

FACTS ABOUT LIVE STORAGE: Live storage, also called capture-based aquaculture, involves catching wild animals and then keeping them alive or feeding them until they are harvested.

The aim is to increase the biomass, enhance the raw material quality and the opportunity to perform strategically in relation to the market by being able to determine when the fish are harvested and sold.

For instance, the cod fishery is characterized by a short and hectic season. If wild cod is caught and kept alive in the cage, it is possible to ensure a supply of fresh cod to the markets year-round and not only during the short fishing season.



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Controlling fish oil quality

New quality analyses give more realistic measurements of rancidity in fish oils and enable the industry to perform better quality control.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

In the battle for omega-3 resources, it is important to focus on quality and optimal use so there will be enough omega-3 oils in the future.

High quality fish oil has little taste and is difficult to distinguish from ordinary cooking oil. In the presence of oxygen and light, the oil will turn rancid (oxidize) and develop an undesirable taste and smell. Fish oil is particularly rich in healthy long chain polyunsaturated omega-3 fatty acids, making it particularly susceptible to rancidity. When polyunsaturated fatty acids turn rancid, a complex mixture of small molecules forms, producing unwanted smell and taste.

“The approved standard analytical methods for rancidity (peroxide and anisidine value) are inadequate to ensure high quality of fish oils. A range of analytical methods must be used in order to gain a picture of the oil quality that is as correct as possible,” says Research Scientist Stine Grimmer.

Scientists in Nofima Lipid Platform, a strategic research programme, have developed alternative quality analyses that measure the content of specific oxidation

products in the oils. The methods have been tested on a number of different types of fish oils with various degrees of rancidity, and then compared with standard analytical methods. The new quality analyses are able to document the rancidity to a greater degree than the original methods.

Why is knowledge about the degree of rancidity in fish oil so important? Rancid fish oil with unwanted taste and smell can lead to less people taking fish oil. Following digestion in the stomach, a capsule of oil of poor quality can cause regurgitation of rancid taste. Reduced quality of fish oils can also result in diminished health benefits of omega-3 fatty acids.

“There are indications that rancid oil inhibits the cells’ own antioxidant system and reduces the anti-inflammatory effect of omega-3 in cell models,” concludes Grimmer.



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Keeping a lid on cured sausage

Nofima joined the team when Grilstad developed new packaging for its popular cured sausages.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Hanne Larsen with the Grilstad packaging.

When Grilstad decided to modernise the packaging of its most popular cured sausages, it was natural to involve Nofima in the job of troubleshooting and quality-assuring the new pack.

Grilstad performed a consumer survey, from which it emerged that the packaging was one of the products' weakest points. The packs were difficult to open, they tore when you opened them, the opening and closing functions did not work and they did not stay sealed. If the pack is not well enough sealed, too much oxygen will get in and the product will dry out and become discoloured. Grilstad wanted to do something about this and they found the solution in a German butter pot with a screw top.

However, the German version was not suitable for cured meats and some improvements were needed. Among other things, the gas barrier that should prevent oxygen reaching the product needed improvement.

Nofima Research Scientist Hanne Larsen has been working for several years on gas transmission in food packaging. She got the job of quality-assuring the documentation of the new packaging for Grilstad's cured sausages.

"My job was to make a theoretical assessment of Grilstad's packaging choice, so that we could minimise the risk of the product discolouring," says Larsen.

As part of quality control, Larsen also performed tests with varying amounts of oxygen in the packs.

"These packs were then exposed to normal supermarket lighting, so as to increase our understanding of when the product becomes discoloured and what is needed to maintain the best possible product quality from arrival in the supermarket to consumption at the breakfast table," says Larsen.

Grilstad launched its new packaging onto the market in September 2013.



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Grilstad

MORE INFO:
Article about colour
changes



A taste of seafood souvenirs

With food increasing in popularity as souvenirs, Nofima is helping the seafood industry to develop food products for tourists to take home.



PHOTO: BJØRN TORE FORBERG © NOFIMA

King Oscar wants to test whether Lofoten cod liver and Lofoten cod liver pâté catch on among tourists in Norway.

Nofima has carried out a comprehensive study of tourists to identify what type of souvenirs they wish to take home from Norway. The scientists interviewed representatives from restaurants and food retailers as well as tourists.

“Tourists don’t only want to take home handicrafts and postcards of the Midnight Sun. Food is an important part of the holiday experience and it is also important as a souvenir,” says Scientist Trude Borch.

TAILOR-MADE FOR TOURISTS: But food products must be adapted for the purpose. They must be durable and correctly packed. The tourists want food souvenirs that are small, do not smell and in packaging that does not leak. They also want the souvenir to tell a story.

In collaboration with the canning company King Oscar, the Nofima scientists have developed a prototype of a culinary souvenir. The product is a well illustrated box containing a can of Lofoten cod pâté and a can of Lofoten cod liver. The package features the Norwegian

flag, a picture of King Oscar and the story about the cod that comes to Lofoten to make love and spawn. There are also serving suggestions for the pâté and the cod liver.

PROTOTYPE PRESENTED ON HURTIGRUTEN: The prototype was presented on the Hurtigruten ship MS Midnatsol in June. As well as positive response from tourists, the scientists received feedback on the prototype from the Hurtigruten managers. They were satisfied with the product, but also had suggestions for improvements.

The prototype is now tested in four of the project’s partner enterprises. Further tourist surveys will be undertaken as part of the ongoing work.

“We hope that this project can inspire innovation in the tourism and seafood industry with respect to food souvenirs. There is clearly a market for good food souvenirs and existing products have the potential to be adapted to this market,” says Borch.



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 Innovation
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Which food fills you up?

Using sensory assessors, scientists have found it possible to measure satiety objectively. They tested porridge made of oats or wheat.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Neither the sensory assessors, represented here by Vicky Berg and Kristin Enger, nor the consumers ate breakfast before the porridge at 8am.

Nofima's sensory assessors are renowned for their well developed senses and, as a panel, are an objective measuring instrument. The assessors normally assess the smell, colour and appearance of products, but they are now assessing satiety – the sensation of feeling full – in an objective manner.

"We wanted to see whether it's possible to use the sensory assessors to measure satiety and compared their results with the perceptions of ordinary consumers," says Research Scientist Valérie Lengard Almli.

Four different porridge mixtures were tested, each with 53 g cereal per portion. These were oat porridge based on flakes, oat porridge based on finely ground grain (flour), wheat porridge based on flakes and wheat porridge based on sifted flour.

OBJECTIVE MEASUREMENTS OF SATIETY: Before they started the tests, the scientists assumed that oat porridge was more filling than wheat porridge, that flakes were more filling than flour and that the sensory panel was better at measuring fullness than consumers.

Some of these assumptions proved to be correct, but

not all. The sensory panel is better than the consumers at measuring and differentiating satiety into several sensations. As such, the assessors may be used as an objective measuring instrument of satiety. While the ordinary consumers did not manage to detect satiety differences between the various porridges, the sensory panel had a clear verdict.

When it comes to flakes versus flour and oats versus wheat, the picture is more nuanced. Right after the porridge breakfast, the assessors feel fuller from the porridges based on wheat flakes and oat flour, but as time passes the feeling evens out between the four porridges. Overall, for a period of 3.5 hours, wheat flake and oat flour porridges provide the least feeling of hunger, closely followed by oat flake porridge with wheat flour porridge last.

This study forms part of the strategic programmes "Sensory strategies and consumer insight for healthy and palatable food" and "Dietary fibre and glycaemic carbohydrates" as well as the competence project "Oats in the prevention of metabolic syndrome".



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Breeding fearless farmed fish

Scientists have studied the individual behaviour of Atlantic cod to find out if we can breed a fish more adapted to a life in aquaculture.



Scientist Tale Marie Karlsson Drangsholt and colleagues have studied the heritability of the cod's behaviour.

Terrestrial livestock are so different that they often have nicknames, but thousands of farmed fish look so similar that many are surprised when biologists claim that fish may have different "personalities" too.

Sometimes understanding what happens in a large group of farmed fish is only possible by studying individual fish. How the fish react to stressful or life-threatening situations indicates how robust or fearless they are to tackle life as a farmed fish. A typical fear response is that the fish stops to determine how dangerous the situation is.

In a project called MARWEL, the Nofima scientists studied the extent of such behavioural differences between cod families. The scientists measured the fear response of individual fish in 15 different families, and then calculated the heritability of the behaviour of the fish.

"This pilot study showed a large variation in the response of individual fish and clear differences between

the families. All the cod reduced their swimming speed and moved towards the edge of the tanks when they sensed fear. Some were not particularly scared and soon returned to their normal behaviour, but for others the reaction was both strong and long lasting. These are fundamental characteristics that will probably follow the cod throughout their whole life. Genetics accounted for 20–30% of the variations in the swimming activity," says Director of Research Ingrid Olesen.

The scientists use advanced video technology to study how individual fish react.

"This trial showed that breeding can be an important tool for developing a fish with good and desired behaviour, but we still have insufficient knowledge about what influences these individual differences and which characteristics we can breed for," says Scientist Tale Marie Karlsson Drangsholt. There is, therefore, a need to study this in a larger trial involving more families of farmed cod.



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Resisting lice is top priority

The majority of Norwegian households regard resistance to salmon lice as the most important welfare trait in commercial breeding programmes.



PHOTO: KJELL J. MEROK © NOFIMA

In the long term, the salmon farming industry can profit by considering ethical values in breeding programmes, by enhancing its reputation.

As part of the Breedwell project scientists from Nofima, amongst others, have asked Norwegian households about the value of fish welfare and which welfare traits are most important. In an internet survey, a representative section of 770 members of Norwegian households were asked how much additional tax they were willing to pay annually to ensure Norwegian salmon is bred for various traits that improve fish welfare.

It was a hypothetical question, but the responses provided the scientists an indication of how important Norwegians think fish welfare is, and which traits are most important. Salmon breeding programmes currently focus on increased weight, fillet quality, health and the ability to resist salmon lice.

The survey participants could choose between the following four traits:

- ability to resist salmon lice
- ability to resist infectious diseases
- less aggressiveness to avoid injuries
- fewer fish with deformities

The “ability to resist salmon lice” scored highest, followed by the “ability to resist infectious diseases”. All the respondents were willing to pay extra tax to improve these traits genetically.

WHY SALMON LICE?: “A possible explanation for why people regard salmon lice and infectious diseases as most important may be that breeding for these traits can reduce the use of medicine in fish farming, increase fish welfare and reduce the spread of lice to wild salmon”, says Project Manager Hanne Marie Nielsen.

The survey coincided with salmon lice gaining considerable media attention, which may have made people especially aware of salmon lice.

In order to find how much weight to place on traits when selecting fish, the scientists generally calculate the extra profit obtained by a fish farmer by improving a trait. Because ethical values of fish welfare are not priced in the market, they asked about willingness to pay tax to support breeding programmes for increased fish welfare.



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Beta-glucan and immune defence

Scientists have developed a method to determine if immunological responses of different beta-glucans are related to the intact glucan-chain.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Now a post doc, Anne Rieder is studying techniques to maintain the molecular structure and properties of beta-glucans in various products.

Beta-glucans are a group of dietary fibres found in barley, oats, fungi and yeast, among other things. They consist of glucose molecules that are joined in such a way that they cannot be broken down by the body's own enzymes. Beta-glucans are a heterogeneous group and the structure of these macro molecules varies depending on where they come from. Consequently, variations in the biological effect are expected.

"Like many others, we have used in vitro studies to study the immunological mechanisms. These are often sensitive to contamination of the samples, which can lead to false positive results," says Anne.

A new method has been developed that makes it possible to see if the measured effect is related to the beta-glucan itself. "Specially selected enzymes are used to cut the chains. If the measurable biological effect disappears, we know that it is the chain that is working, and consequently the beta-glucan," says Anne.

DEVELOPED A GENERIC METHOD: The method is generic, meaning it can be useful for any research wanting to study which macro molecules in food and dietary supplements could have a specific effect on immune defences.

"We found that the effective mechanism for cereal beta-glucans was different from what we thought, but particulate yeast beta-glucans appear to be able to affect epithelial and immune cells directly, so we need to continue searching for what other mechanisms cereal beta-glucans might have," says Anne Rieder.

When the scientists arrive at the correct effective mechanism for the various beta-glucans, the next step is to isolate beta-glucans with special characteristics that can be used in food, so as to maximise the effect.



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MORE INFO:

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Data that provides direction

Nofima carries out an annual survey of profitability in the fishing industry, which is of major benefit to the industry and public administration.



PHOTO: FRANK GREGERSEN © NOFIMA

Nofima's database is important for understanding the situation in the fishing industry and forms the basis for many important assessments.

The extensive information linked to catch patterns, structure, production and profitability in the fishing industry has been built up over 40 years. This database provides unique possibilities to perform analyses and test economic models.

POLICY PRIORITIES: "This survey is extremely important so politicians can gain an understanding of the situation in the fishing industry. The results provide background material for Ministers of Fisheries to develop policies for the fishing industry," says Bjørn Inge Bendiksen, who has for many years worked on the annual survey of profitability.

Nofima has also used the data to evaluate the effect of many public measures, leading to the role of secretariat for an official Norwegian report on the framework conditions for the Norwegian seafood industry, to be presented in 2014.

The industry's organisations and various financial institutions emphasize the annual survey of profitability in

their planning. It also forms the basis for many research projects and economic analyses carried out by Nofima.

THE TALE OF THE FIGURES: Despite many reports, the seafood industry still struggles with profitability. But the scientists can gain a lot from the figures and statistics.

"There is an abundance of opportunities and challenges. The problems in the Norwegian seafood industry are primarily due to the financial crisis in many important markets, high labour costs and seasonal fluctuations," says Director of Research Bent Dreyer.

With cod stocks at record levels, by the end of April 2013 an additional 30,000 tonnes of cod had been caught compared to the same time last year.

"When nearly 50,000 tonnes of cod is landed in 14 days, naturally this creates challenges regarding quality, logistics and markets," says Dreyer.

One of the solutions Nofima is researching to reduce the negative effects of such intensive seasonal fisheries is capture-based aquaculture.



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Taste interaction in meals

A doctoral thesis demonstrates the importance of understanding the effect of different flavours in food when they are combined in a meal.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Kristine Myhrer and Morten T. Paulsen prepare beer samples for a test to see if choice of beer influences the liking of soups.

Food producers measure the consumers' liking of their products by testing these individually. The products may be experienced differently in combination with other products in a meal. It may also be difficult to measure flavour sensations in several products simultaneously, and how flavour can change over time.

"Increased knowledge about sensory interactions in meals may help the industry to develop new and healthier food and drink combinations with improved sensory properties. What is most important in such studies is of course to find out what people like to eat," says PhD candidate Morten T. Paulsen.

First he studied how the flavour of salmon is affected by varying the basic tastes in sauces accompanying it. The flavour changed with different basic tastes. The combination with salt, for example, showed that the flavour of fish and fish oil in salmon was significantly reduced.

The interaction between salmon and sauce was also investigated in a dynamic method, where one describes

how the flavour develops while one chews the food and the aftertaste after spitting it out.

"The timing for when specific properties dominated had a great effect. If a sour taste was perceived early in the chewing stage, the consumer was of the opinion that this was positive. If the sour taste emerged late in the chewing stage, it was perceived as negative," Paulsen says.

Paulsen also investigated dynamic perception between samples with minor sensory differences, which is relevant in the case of recipe changes to e.g. low-salt products. The results indicated differences between the samples, which are not detected by conventional sensory profiling.

Sensory interactions between two different types of beer and soups differing in the basic tastes were also investigated.

The results showed no clear interaction in relation to the various basic tastes, but the beer types influenced consumer acceptance of the samples.



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about sensory
science



Seeking optimal salmon diet

Scientists are seeking good substitutes for the marine ingredients in salmon feed due to restricted resources from the sea.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Scientists are seeking answers about the amount of the omega-3 fatty acids EPA and DHA that salmon and trout need to maintain good health.

Aquaculture is one of the fastest growing food producing sectors. A major limitation to further growth is the scarcity of fish oils for use in fish feed. Scientists are seeking answers about the safe lower dietary levels of fish oils that secure the salmon and trout good health.

They have collated the current knowledge and identified what knowledge is needed in order to know the fish's minimum needs for EPA and DHA. More than 200 scientific publications have been reviewed. It is documented that the fatty acid composition of feed is important for fish welfare, but we do not know the optimal dietary fatty acid composition required to secure good disease resistance.

"We need knowledge about which fatty acid compositions that makes the fish less susceptible to stress and viral and bacterial infections. We also need more knowledge about the long-term effects of low EPA and DHA levels in feed on fish health," says Nofima Senior Scientist Bente Ruyter.

DIFFERENT REQUIREMENTS IN DIFFERENT LIFE STAGES:

Salmon and trout have several vulnerable life stages, such as the early larval stage, smoltification and sexual maturation. More knowledge is needed about the nutritional requirements in these phases.

In the freshwater phase, the fish need a minimum of 1% EPA and DHA in the feed. In the seawater phase, studies indicate that salmon tolerate high levels of various plant oils in the feed without negative effects on growth. However, the knowledge about long-term effects on fish health is inadequate, as the majority of trials are limited to short phases of fish life.

"Knowledge about epigenetic regulations (or changes in DNA that are expressed in later life stages and transferred to the next generation) can be an important part of the future work to optimize the potential of salmon and trout as good net producers of EPA and DHA," says Ruyter.



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Purse seine fleet can add value

Quality improvement giving a 10% better price would have increased the catch value of mackerel and herring by around NOK 380 million in 2011.



PHOTO: FRANK GREGERSEN © NOFIMA

Technology that enables the purse seine fleet to land larger and fatter herring can provide major economic benefits.

This is the conclusion of a report by Nofima scientists who analysed the Norwegian purse seine fleet.

The report is part of CRISP, a centre for research-based innovation in sustainable fish capture and pre-processing technology. The goals of CRISP are to add value to the Norwegian seafood industry and reduce the strain on the environment.

“The potential for added value lies primarily in improved quality (size and fat content) of the landings. New technologies that enable the vessel to catch the desired quality and contribute to increasing the prices of the lowest paid deliveries up to the average price will constitute a combined annual increase for mackerel and Norwegian spring-spawning herring of around NOK 50 million,” says Director of Research at Nofima, Bent Dreyer.

ENERGY CONSUMPTION: The purse seine fleet currently has the lowest energy consumption in relation to catch volume.

The total fuel costs for the purse seine fleet were approx. NOK 380 million in 2010. The largest component of the fuel consumption is the distance between the fishing grounds and the point of delivery, but fuel consumption for locating the fish is also high.

If CRISP can contribute technological solutions that make it easier to locate and catch the desired fish that reduce fuel consumption by 10 percent, this will constitute an annual saving for the fleet of NOK 38 million.

OWNERSHIP: The size of the purse seine fleet has remained stable at 80 vessels since 2008. Since 2008 there has been no acquisition of quotas for transfer from one vessel to another in this fleet.

“The ownership of purse seine licenses is extremely fragmented, and an ownership group (often a family) often owns only one vessel. The 17 largest ownership groups controlled just 51% of the rights in 2011. This is a far lower concentration than we find, for instance, in the cod trawling fleet,” says Dreyer.



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Fishing luck in a tube

New sustainable bait enables anglers to rub a scent on their hook to more easily attract fish such as cod, salmon and halibut.



PHOTO: © POLYBAIT

Unique by-products from the fisheries industry are behind the scents now available in different tubes.

The bait is a cream sold in tubes. The content is extracted from marine by-products. The new bait for anglers was developed by entrepreneur Svein Kvalvik from Lofoten in collaboration with scientists and industry partners.

“After many trials, we arrived at three types of bait with different scents that the fish like. The three baits are specially adapted for cod, halibut and trout/salmon/charr. This is the first angling bait on the market that is scientifically proven,” says Nofima Senior Scientist Sten Siikavuopio.

Over the past year he has extracted many different scents from marine by-products and studied how various fish react to them.

BREAKS DOWN: The thinning agent that enables the scents to be applied in the form of a cream was developed at SINTEF Materials and Chemistry in Oslo. The

cream biodegrades in water over time. This is to prevent the fishing gear from attracting fish for all eternity in the event that the line snaps. The scientists have also ensured that it doesn't dissolve too quickly in water.

SELECTIVE: “The bait has the properties of natural bait, doesn't cause pollution and is biodegradable. We use by-products from fish production so we are not putting a strain on the fish resources for edible fish. By replacing fish as bait, we will contribute to reduced greenhouse emission, improved returns in long-lining and the opportunity for selective fishing,” says entrepreneur Svein Kvalvik.

He originates from Kvalvik in Lofoten and gained inspired from his home fishing environment.

Kvalvik's company Polybait has launched the first bait for anglers, and future plans include bait for the commercial long-lining fleet.



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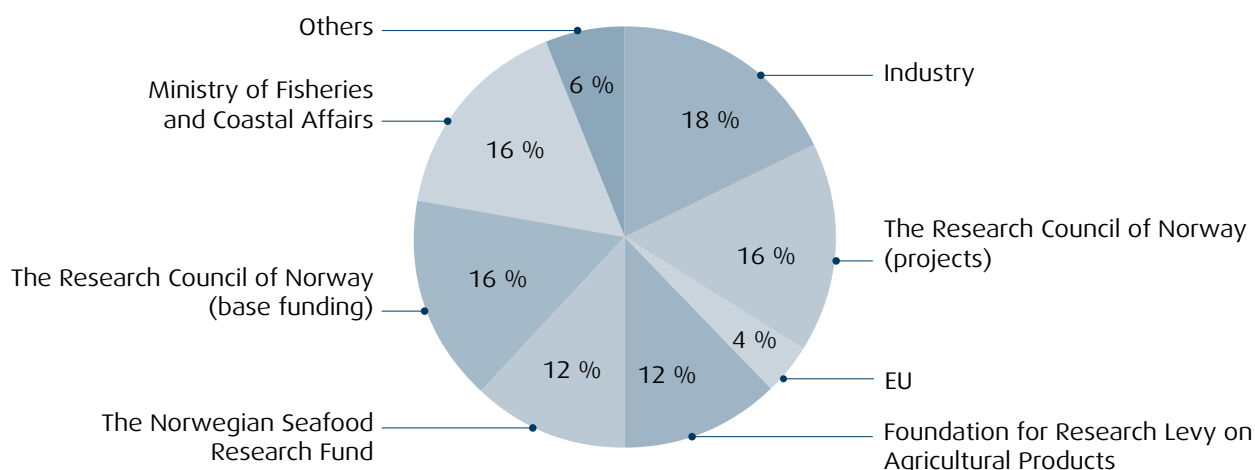
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MORE INFO:
 Video of the trials



Facts and figures

In 2013 Nofima's 400 employees delivered research and services worth NOK 535 million to approx. 240 different clients in Norway and abroad.



The following are our largest funding providers:

RESEARCH COUNCIL OF NORWAY is a strategic organ that identifies priority areas and project/programme managers, allocates research funding and evaluates the research that is carried out.

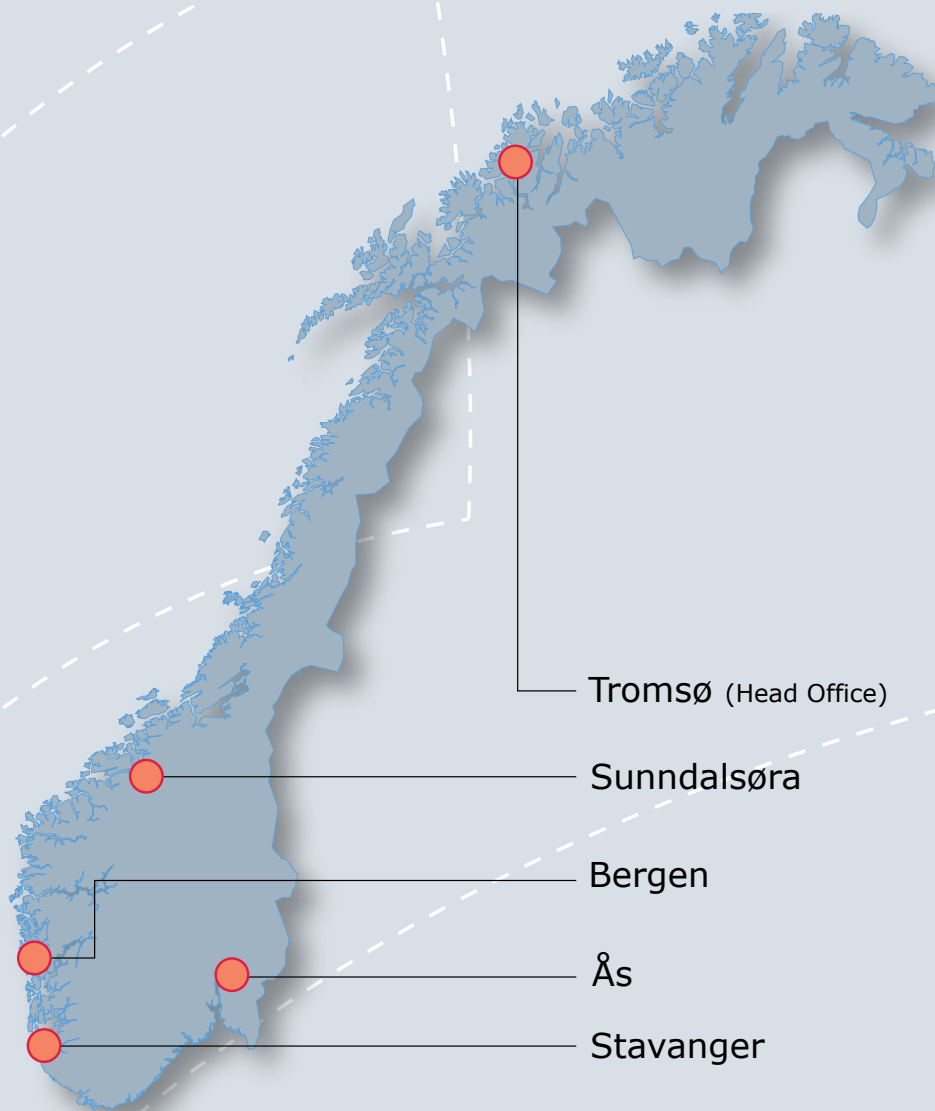
THE MINISTRY OF FISHERIES AND COASTAL AFFAIRS is responsible for the fishery and aquaculture industry, fish health, fish welfare, seafood safety and quality and more.

THE NORWEGIAN SEAFOOD RESEARCH FUND (FHF) shall create added value for the seafood industry through industry-oriented research and development. Financed through a levy on all seafood exports.

THE FOUNDATION FOR RESEARCH LEVY ON AGRICULTURAL PRODUCTS (FFL) shall secure an economic basis for research connected to agricultural products that are utilized to produce food and stimulants, as well as feed grain for animals. Financed through a research levy on agricultural products.

THE INDUSTRY – Nofima's R & D work is oriented primarily towards the aquaculture, fishery and food processing industries.

THE EUROPEAN UNION finances several research projects that Nofima either participates in or has project responsibility for.



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