

Creating value

Project year 2016



32
examples of
useful
research





Fish and folk

In 2016 Nofima wrote the book “Fisken og folket” (Fish and folk) about developments in the cod sector, and the interaction between the fishing fleet, the fishing industry and the fishing communities. The book provides good insight into the impact of Norway’s fisheries policy and other trends on the industry. It also provides an important factual basis on which to discuss developments in the industry, while identifying political choices that the industry will face in coming years.

“Fish and folk” is a result of the Fishery and Aquaculture Industry Research Fund (FHF)’s project “Increased profitability in the cod sector”, but also builds on nearly 40 years of studies of profitability and structural developments in the fishing industry in Norway. The book is published by Orkana and is available – in Norwegian language – in bookshops and online.



Research must be useful

Welcome to this year's edition of Creating value. Nofima is an applied research institute, and for us it is important to maintain close dialogue with our customers and clients. This gives us insight into the needs for research and innovation, and helps us deliver relevant research with high utility value.

This edition presents 32 of our most exciting research projects in 2016, all of which demonstrate our focus on utility value. To ensure projects are relevant we nurture close relationships with players in the industry and develop our strategic priorities in line with the industry's needs.

With a view providing our industries with the specialist expertise necessary to deliver products of the highest quality, Nofima has recently launched two new priority areas: future protein production from residual raw materials (Peptek) and rapid measurement for process optimisation (Spektek), both organised as internal "Centres of Excellence". Here we shall deliver world-class research.

The Spektek team will be looking into spectroscopy and other rapid, non-destructive measurement methods for process optimisation. In simple terms, spectroscopy is a method in which light is passed through a food product, enabling rapid analysis of the quality. This helps producers ensure that the consumers get consistent quality.

Peptek will be studying proteins and peptides (chains of amino acids) in residual raw materials. This is the essence of the circular bioeconomy. New research-based knowledge shall enable us to exploit what we catch and grow to the maximum. Nofima's research facilities enable our researchers to deliver world-class knowledge.

We measure our success in the results that our research provides for our customers.



Øyvind Fylling-Jensen
Managing Director



PHOTO: AUDUN IVERSEN © NOFIMA



32 examples of useful research

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Healing wounds with eggshell membranes

Developing a commercial, affordable wound-healing product based on eggshell membrane is a brilliant example of reuse of rest raw materials.

Nofima scientists are participating in an international project led by the biotechnology company Biovotec. The goal is to develop a wound-healing product for chronic wounds – a major and growing problem.

“Today’s wound-healing products are either very expensive or they do not work well on chronic wounds. Our goal is to offer a treatment option for people who currently have to live with a lot of pain,” says Ralf Schmidt, the founder and managing director of Biovotec.

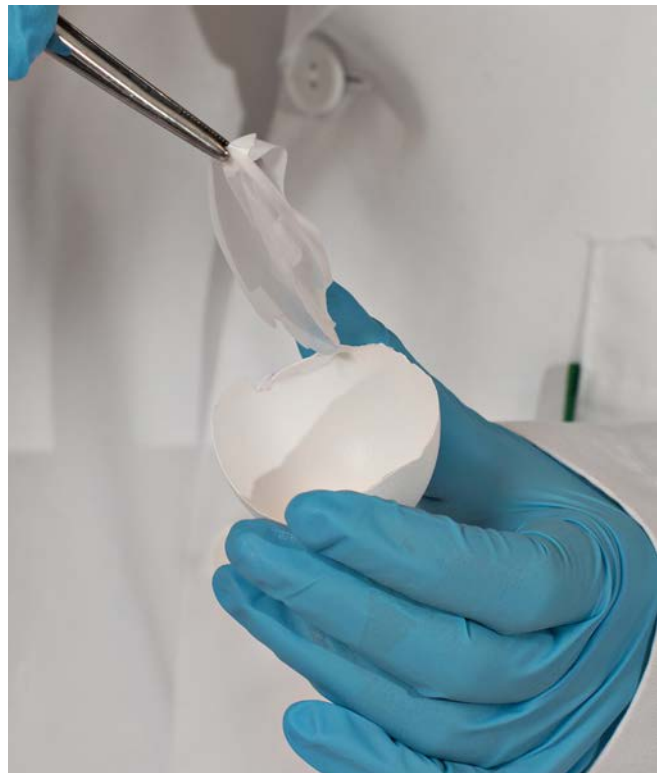
New knowledge about cells opening new possibilities

Diabetics often suffer from wounds that do not heal, in part because of an imbalance whereby the cells that produce a kind of matrix do not work properly. The membrane found on the inside of eggshells fulfils the same function as the matrix and has been known for its wound-healing properties from ancient times.

Biovotec’s wound-healing product is based on a patented mechanical separation method. Once the membrane has been removed and activated, it is ground down to a powder. It is this powder that Nofima scientists are testing.

“We are studying the wound-healing effect of the powder on cell culture models to investigate the activity and underlying mechanisms of the membrane powder. In our cell models, we see that the powder stimulates various cellular activities that are necessary to heal wounds,” says scientist Mona E. Pedersen.

Nofima scientists have been working on matrix and bio-



PHOTOS: JON-ARE BERG-JACOBSEN © NOFIMA

The wound-healing product under development will cost about a quarter of the comparable products that are currently available.

logical activity for a long time. They have developed cell models that make it possible to reveal the cells’ signals and the mechanisms of the eggshells membrane.

Reducing the need for animal testing

“Cell studies allow us to study everything at a cellular level. It is not possible to map the same mechanisms in animal tests. Cell experiments are also much cheaper and provide an initial indication of what might work well for animals and humans,” explains scientist Sissel B. Rønning.



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See article





▲ Scientist Tone Aspevik in Bergen has tested and compared several enzymes based on cost and the enzymes' ability to cleave salmon proteins

◀ Nofima scientists in Ås working on hydrolysis of chicken bone protein. From left: Sileshi Gizachew Wubshet, Nils Kristian Afseth, Diana Lindberg and Ulrike Böcker.

Promising proteins

Today many companies use off-cuts from fisheries, aquaculture and meat production, but often with little financial gain. We see a potential for much greater gains. In the future off-cuts will be regarded as a commodity, not leftovers, according to Nofima scientists.

Nofima is researching how the food industry can use residual raw materials and add value through bioprocessing, while at the same time reducing the loss of valuable nutrients, such as proteins that can be used for feed and food.

The proteins in freshly slaughtered fish and animals are of excellent quality. To exploit this potential once the fillets have been removed, the residual parts must be treated properly. In addition, the process of extracting the proteins from the carcass must be optimal. Enzymatic hydrolysis is one such process. To ascertain whether this process is optimal, it must be measured and the final product must have the appropriate qualities, including flavour.

A top-quality end product means more of the residual raw material is used for human consumption and other better paying markets. If the end product contains bioactive substances, we can determine whether it can be used in feed, health foods or medicinal products. The research is still ongoing, but Nofima already has some interesting findings.

Enzyme-tailored products

In enzymatic hydrolysis, enzymes are a catalyst that open up the protein structure and cleave the proteins. The scientists choose the enzyme based on the kind of end product they want.

"By using enzymes, which act like tiny biological scissors, you can cut up the proteins found in residual raw materials into smaller peptides. These peptides are more easily soluble in water and therefore easier to exploit in products such as dietary supplements, soups and baby food than intact protein," explains Tone Aspevik.

She completed a PhD in optimisation of the enzymatic hydrolysis process in 2016. Aspevik conducted a systematic study to determine which enzymes and process conditions yield protein powder with an acceptable flavour at the lowest cost. Her project focused on protein powder from salmon trimmings. The knowledge gained from this work is now openly available for industrial use.

An important part of the solution to ensure good quality of the end product is to have analysis methods that enable better continuous monitoring of the protein quality.

A team of scientists at Nofima, led by Nils Kristian Afseth,

have developed a brand-new, promising analysis method based on spectroscopy. This technology uses light to analyse the chemical composition of samples without affecting the process or the raw material.

The scientists are using this technology to study the changes in protein structure and chain lengths, enabling the scientists to increase their understanding of what actually happens during enzymatic hydrolysis.

Real-time quality analysis

"The difference between the method we are working on and the existing methods is that our method makes it possible to verify the quality during production. In this way, our industrial partners can continuously adjust the process, resulting in products with optimal quality and maximum yield," says Afseth.

To be able to find the most suitable peptides at any given time, the Nofima scientists are working in a multidisciplinary team. In 2016 Nofima established a multidisciplinary collaboration as part of a self-funded research initiative within the circular bioeconomy called Peptek, headed by Ragnhild Dragøy Whitaker, head of marine biotechnology research.

"There are major opportunities for increased exploitation and profits by processing off-cuts to create high-quality protein. In the future off-cuts will be regarded as a commodity, not leftovers," concludes Afseth.

Residual raw materials

- Residual raw materials from food production are everything that is left over after the main products have been removed from the animal, fish or plant. Nofima is working on all these raw materials.
- Bioprocessing involves using biological components (yeast, enzymes, etc.) to process and convert raw materials into new products, such as proteins, peptides and oils.
- Nofima is working on extracting components such as:
 - Various proteins (for example, collagen)
 - Oils and fats
 - Phosphorus and other micronutrients
 - Functional molecules such as antioxidants and vitamins



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South Korea wants live seafood

Live Norwegian crab is popular, but the competition is tough. Research is providing valuable insight for companies that want to enter the Korean market.

Live seafood is very popular in many parts of the world and commands a high price. Norwegian export of live seafood is relatively new, but now sales are really taking off, especially for crab. In 2016 almost two-thirds of the king crab catch was sold alive at the staggering export price of NOK 220 per kg, mainly to South Korea.

In order to gain insight into why Norwegian crab has become so popular in such a short time, and how its position can be further strengthened in the market, Nofima market scientists have conducted in-depth interviews with South Korean importers and buyers for supermarket chains.

Competition

"Koreans love Norwegian crab. They like the quality of the crab and they like dealing with Norwegian exporters, as well as being glad of competition among the suppliers," says scientist Bjørg Helen Nøstvold.

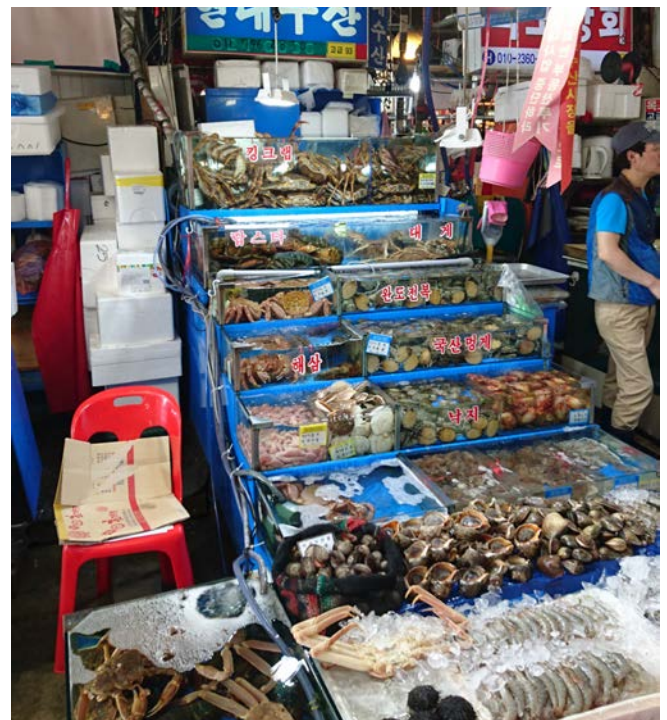
Norwegian crab faces stiff competition, primarily from Russia, which has been exporting live red and blue king crab to Korea for decades. While Norwegian crabs are packed alive

in crates and flown to Seoul, Russia delivers crab directly by boat. They thus have the advantage of delivering only live, uninjured crab and take injured or dead crab back. South Korea also has its own crab fishery.

Good reputation

Koreans do not eat all the crab themselves. Roughly half of the imported crabs are resold, mostly to other Asian countries. A high meat content is essential, in terms of sales, price and survival. The scientists also believe it would be beneficial for Norwegian crab companies to adapt to the Russian and Korean crab-fishing seasons. In addition, the companies can also benefit from the fact that other Norwegian species are already well established and known.

"Norwegian salmon and mackerel have a good reputation in South Korea. Norwegians are regarded as honest and reliable, and while this benefits the crab companies, it also requires a commitment to the market. Long-term relationships are a prerequisite when doing business in Korea," says Nøstvold.



PHOTOS: INGRID KVALVIK © NOFIMA

Norwegian crab is very popular at the seafood market in Seoul, which features seafood of all kinds, the best of which is sold alive.



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Scientific collaboration: University of Stirling.



In June the +Grønt products was launched at Choice Hotel Christiania in the presence of the Norwegian Minister of Agriculture and Food, Jon Georg Dale, who was most impressed with both the flavour and the opportunities for value creation.

New flexitarian favourites

With this new product category, containing up to 50% vegetables, people who wants to eat a bit more vegetables get more easy options.

The first product in the +Grønt series is meatballs made with 33% vegetables. They are currently only available to hotels, restaurants and canteens, but the research project participants in "GRØNTIKJØTT" are hoping that +Grønt products will soon be available in grocery stores too.

"The aim of the project is to develop a new product category: sustainable, healthy everyday products consisting of ground meat and a high content of vegetables," explains Nofima scientist Grethe Iren Andersen Borge, who is leading the multidisciplinary team of scientists at Nofima in the project.

Healthy and eco-friendly

Cauliflower is a key vegetable in the +Grønt meatballs. Undersized florets are discarded when cauliflower is cut and deep-frozen by the industry. For cauliflower alone, the company has 30 tonnes food waste per year. These are now used and thereby preventing food waste.

+Grønt uses perfectly good vegetables that cannot be sold as they are, simply due to their size or appearance. Now,

instead of being used for animal feed, as is often the case today, the vegetables will be used in the +Grønt products.

"The research is on optimisation of raw material combinations, processing and storage, and the effects on sensory, microbial and health-related quality," says Borge.

Added value for Norwegian meat and vegetables

The food company Jæder is the project owner and is launching the +Grønt series. They expect to increase their sales to existing customers by some NOK 100 million a year and also see a potential in new customer groups.

"We want to be a pioneer that creates added value for both Norwegian meat and Norwegian vegetables through processing in new and innovative ways", says marketing manager at Jæder, Guro Espeland, who is the project manager.

They will achieve this by working closely with Nofima and the companies at various levels in the value chain.



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New feed beats discolouration

Each year fish farmers lose vast sums of money because of dark spots in salmon fillets. Leaner, protein-rich feed may offer a solution.

Dark spots – melanin pigmentation – in salmon fillets were first noticed more than 20 years ago. Recently there has been a marked increase in these dark spots, and they now pose a serious quality problem. The increase coincided with significant changes in salmon feed, combined with more frequent outbreaks of pancreas disease (PD) and heart and skeletal muscle inflammation (HSMI).

Nofima has previously found that changes in feed can halve mortality from natural outbreaks of PD and HSMI.

But could changes in the salmon's diet also reduce the incidence of melanin spots in the fillet?

Convincing

"Melanins are naturally occurring, useful pigments with an antioxidant effect that protect various types of tissues and are thus an important part of the salmon's immune system. Since a lean, protein-rich test feed was found to improve disease resistance, we investigated whether this feed could also prevent the formation of melanin spots. Salmon were fed with the test feed or ordinary feed before, during and after

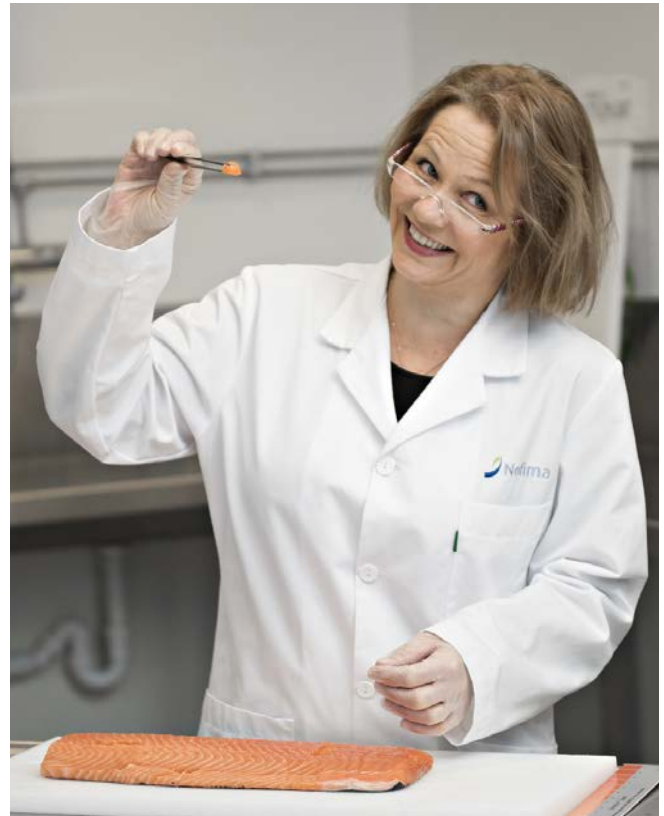


PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

"Even a modest reduction in dark spots in fillets will lead to major financial savings for companies," Turid Mørkøre points out.

a natural outbreak of disease with co-infection of the viruses PRV and SAV3. 2,600 fillets were examined," says the head of the research project, senior scientist Turid Mørkøre.

The findings are very convincing: The change in the feed reduced melanin spots from 26% to 16%. And perhaps even more importantly: the occurrence of large spots, which are difficult to cut away, was reduced to one third.

Major financial savings

"The change in diet also improved the salmon's outward appearance. In the test group, 91% of the salmon were classified as 'superior', compared with 79% in the group that received ordinary feed," says Mørkøre.

The costs that companies report related to discolouration vary, but collected amount to several hundred million kroner a year.

"Even a modest reduction in dark spots in fillets will lead to major financial savings for companies," Turid Mørkøre points out.



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PHOTO: TROND MORETRO © NOFIMA

Tips to prevent *Listeria* in meat

Nofima has prepared two guidelines on monitoring and preventing *Listeria monocytogenes* in meat production.

The guidelines, both written in Norwegian, have been developed by the project "Control of *Listeria monocytogenes* in the production of animal products". The guides are aimed at employees responsible for production, quality assurance and production hygiene in plants that produce food products that are especially prone to *Listeria* contamination.

Guidelines for risk-based monitoring

The guideline *Monitoring and sampling to improve detection of Listeria in the production of heat-treated, ready-to-eat meat products* focuses on the key elements for monitoring, and aims to provide:

- Manufacturers of ready-to-eat meat products with practical guidelines on monitoring the *Listeria* situation in their plants
- Concrete advice on the establishment and practical implementation of monitoring and sampling, including choice sampling sites, practical sampling and use of monitoring results
- Companies with increased insight and a basis for continuous improvement of procedures to achieve optimal control of *Listeria* in their plants

Guide on prevention elimination of *Listeria*

The purpose of the guide *Prevention and elimination of Listeria in units that handle unpackaged, heat-treated meat products* is to provide a risk-based starting point for efficient prioritisation of resources in connection with eliminating and preventing *Listeria* in the production environment.

Based on the properties of *Listeria monocytogenes* and its route of transmission to heat-treated products, there are four areas where steps can be taken to prevent eliminate the pathogen:

- Prevent *Listeria* from entering the clean zone
- Remove typical *Listeria* niches
- Remove *Listeria* reservoirs
- Prevent *Listeria* from spreading from reservoirs to the product

The guide provides advice on how this strategy can prevent and control *Listeria* in the production of heat-treated meat products.

The project was conducted in partnership with Nortura, the Norwegian Independent Meat and Poultry Association (KLF), Grilstad, ISS Facility Services; Lilleborg, NHO Mat og Drikke, Animalia and the Norwegian Veterinary Institute.



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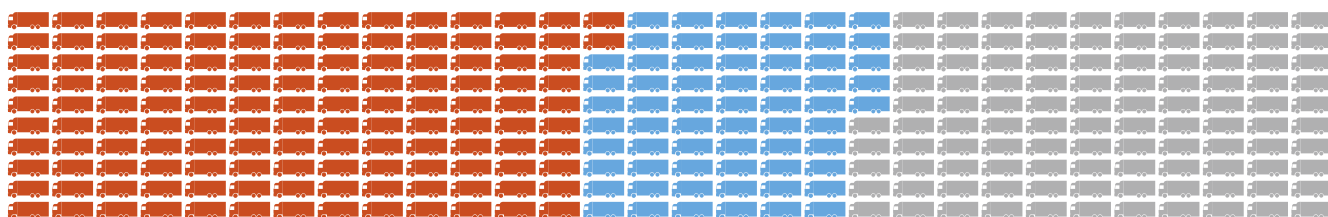
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▲ Today, 85% of Norwegian salmon is transported to the market in Europe as round fish. The plan is to make it profitable to fillet fish in Norway. The crate contains only salmon. Super-cooling means it is no longer necessary to send lorries full of ice out on to the roads.

▼ Transport costs decreases: Of 300 trucks currently transporting salmon in Europe will in a future perspective only 132 leave the Norwegian border (red images). 105 trucks filled with residual feedstock to Norwegian industry (gray cars) and 63 trucks with ice (blue cars), is spared.



Revolutionising Norwegian salmon exports

Stunning, gill-cutting, slaughtering, bleeding, filleting, refrigeration and packaging – all done in 20 minutes.

The ongoing research project Fillet-O may revolutionise Norwegian salmon exports.

“If we succeed and if the industry adopts the methods proposed by the project, it will be a game changer,” says Nofima researcher Bjørn Roth, who is heading and coordinating the potentially ground-breaking research project.

Significantly increased value

Fillet-O, which stands for Fillet Only, is an interdisciplinary research project over four years, the aim of which is to rationalise salmon processing. The goal is to process fish directly to fillets at a lower cost and with higher quality than through traditional slaughtering. Today, some 85% of Norwegian salmon are transported to the international market as round fish. In the future the entire Norwegian salmon production will be filleted on Norwegian soil, creating significant added value.

“The next step is to prove that this is possible, that it is financially beneficial, and that it will benefit and develop the industry. If we succeed, this will definitely pay off,” says Bjørn Roth.

Parts of the industry are already involved as partners in the project.

Plus points

Fillet-O seems to have many plus points: better utilisation of the raw materials, value optimisation, improved animal welfare, better product quality, increased food safety and more efficient transport, yielding reduced costs and environmental benefits.

Production: The entire production process from pen to loading on to lorries takes place in one continuous chain and takes 20 minutes from the fish leaving the sea.

Energy and transport: If you were to sort the contents of 300 lorries containing salmon produced using the current methods, only 132 of them actually contain salmon fillet. 63 lorries contain only ice, and the remaining 105 lorries contain residual raw materials.

“By moving the ice from the crates to inside the fish using super-cooling, whereby a thin layer of ice forms on the fish, the transport of ice becomes superfluous. And if we keep the entire fish in Norway and process it here, we will have enough raw materials to start a whole new industry,” says Bjørn Roth.

New era

The project also aims to ensure improved quality, food safety, shelf-life and market dynamics. The project Fillet-O will end in 2017, and the conclusions will be presented. Bjørn Roth and his partners at home and abroad are already predicting the advent of a new era for Norwegian salmon exports.



PHOTO: JAN INGE HAGA © NOFIMA

Scientists Bjørn Roth (on the left) and Bjørn Tore Rotabakk believe that the research project Fillet-O could revolutionise the Norwegian salmon industry.



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Popular internship scheme

Is it useful for a company to have a Nofima intern? And do scientists benefit from learning more about business? Yes and yes!

Ingelinn Eskildsen Pleym, a scientist in Nofima's consumer and market research department, wanted to know more about challenges and priorities in the business world and how her knowledge can best be used commercially. She therefore spent a three-month internship at Br. Sperre – a major fish processing company.

Positive

"The internship was worthwhile, and we now have excellent relations with the company. I gained insight into some of the current challenges facing the Norwegian fishing industry and learned a great deal. The new competencies I have gained are highly motivating," says Pleym.

"It was very helpful to have Ingelinn here with us. She has given us new insight into how the outside world perceives us and how our surroundings affect us," says Inger-Marie Sperre, managing director of Br. Sperre.

"Scientists contribute to policy formulation, primarily through their influence on politicians. It is therefore essential that they are familiar with our operations and framework conditions – and beneficial for the industry."

Recommended

Scientist Izumi Sone works in the department of processing technology at Nofima.

"I wanted to see research from the industry's point of view and learn more about a company's skills, needs and challenges, to ensure that the research we deliver in the future is business-oriented and useful," says Sone.

This led her to Norway's largest pelagic fishing company, Pelagia.

"I learned a lot about mackerel processing and got to know some highly skilled people at different levels in the



PHOTO: AUDUN IVERSEN © NOFIMA

Scientist Ingelinn Eskildsen Pleym.

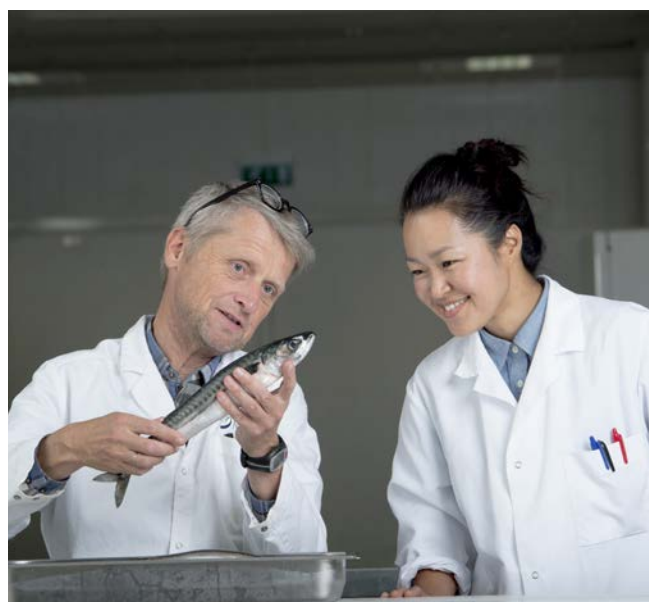


PHOTO: JAN INGE HAGA © NOFIMA

Scientist Izumi Sone – here in conversation with her colleague Torstein Skåra.

company and the work they do, broadening my perspective as a scientist."

The scientists who have had an internship recommend their colleagues – and companies – make use of Nofima's scheme.

"An internship sparks new ideas, and being challenged professionally is good for everyone," says Ingelinn Eskildsen Pleym.

"It is an unbeatable experience," says Izumi Sone.



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PHOTO: TERJE AAMODT © NOFIMA

Scientists at Nofima have a number of practical tips that can help fish farmers improve the smolt's robustness and reduce losses at sea.

Swimming for dear life!

Mortality after transfer to the sea can be prevented at the pre-stocking stage, if fish farmers make a few simple changes.

In 2015 some 41 million salmon died after transfer to the sea in the Norwegian salmon farming sector, according to unofficial figures.

"However, with a few simple changes many of the salmon that die in pens could probably survive and grow to become good food and yield higher profits for the farmers," says Sven Martin Jørgensen, scientist and project manager of the FitSmolt project.

Unfit smolt are more susceptible to disease and more sensitive to handling and stress. By improving the overall health of young fish, farmers will have better quality smolt to work with that are better able to withstand the tougher conditions in the sea. Here are two changes that research has shown are effective.

1: Remove the poorest swimmers

The scientists developed a test to rank the swimming capabilities of salmon parr. The weakest swimmers were found to have poorer cardiac health and shorter gill lamellae than the best swimmers. The scientists found the same differences

over eight months later, and the best swimmers had grown 5-8% more and had significantly fewer ulcerations on their fins than the poorest swimmers. By removing the poorest swimmers at an early stage, the farmers will be left with smolt with both better growth potential and stronger organs for oxygen transport, i.e. more robust smolt.

2: Exercise

Exercise improves the salmon's growth, ensures they develop stronger heart and swimming muscles, and increases their physiological capacity. In the FitSmolt project, the scientists exercised the salmon from the fry stage. The positive effects of exercise were obvious: better growth, a stronger heart and physiology, and a significantly higher survival rate under PD-infection experiments.

"If more fish farmers employed the methods described above, we should see significant, permanent reductions in mortality rates in the coming years," says Jørgensen. "We owe it to the salmon!"



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MORE INFO:
See Nofima's
website



Developing health-promoting bread

Knowledge about function and stability of beta-glucan in dough systems helped Nofima scientists to develop breads for lowering cholesterol.



Scientists in the four-year research project Optifiber have investigated what happens to barley and oat beta-glucan in the bread baking process. They have then applied this knowledge to come up with both a bread recipe and a new baking process that preserve as much of the beta-glucan size as possible.

It took a long time to find the baking method that results in the healthiest bread. The main challenge is that beta-glucan molecules are easily broken down, reducing their health-promoting effect. First the scientists experimented with different recipes to find a tasty bread made with 40% barley. This recipe was then used to test a number of alternative baking processes.

Rising creates problems

"During rising, enzymes that are naturally present in grains start breaking down the beta-glucan molecules. We therefore reduced the amount of time that the barley flour is in contact with water, but always with a clear focus on ensuring good bread quality," says Nofima scientist Anne Rieder.

Adding the barley flour after fermentation of the wheat part of the dough provided excellent results.

Finely ground, coarsely ground or flakes?

The scientists also examined how flours with different particle size affect the molecular weight of the beta-glucan and the quality of the bread. The results are clear: the larger the particles of the barley ingredient, the higher the molecular weight of the beta-glucan in the bread. Barley flakes provided the largest beta-glucan molecules in the finished bread. The next question the scientists need to answer is whether the beta-glucan in large barley particles is as available in the small intestine as the beta-glucan in smaller particles.

"In order to be able to claim that a bread 'lowers cholesterol', the final product must contain at least 1 g of beta-glucan per serving. Our experiments show that it is fully possible to bake barley bread with a high enough beta-glucan content and satisfactory bread quality," concludes senior scientist Svein Halvor Knutsen, who is project manager for the Optifiber project. We are now working on how chain length can be a defined quality parameter for health benefits.



PHOTOS: JON-ARE BERG-JACOBSEN © NOFIMA

Adding the barley flour after the wheat part of the dough had finished rising and the gluten matrix was fully developed provided excellent results.



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PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Farmed salmon need enough marine omega-3 to maintain good health in a typical aquaculture environment with the challenges it entails.

How much omega-3 do salmon need?

Humans and fish need omega-3 in their diets. But supplies are short, and farmed salmon now have less omega-3 in their diet than previously.

The question is just how little marine omega-3 can farmed salmon get by with.

Too little omega-3 can pose a health risk.

Nofima and NIFES have examined all the available data about safe low levels of marine omega-3 in feed for farmed salmon, while still ensuring good fish health. The results are presented in the report "Fats for fish health – 2016".

Multiple factors

In short-term tests on land, researchers have found that the fish can get by with less than 1% marine omega-3 in their diet.

Results from long-term trials in sea pens, indicate that an omega-3 content of 1.6% and over does not have a negative impact on growth or survival. It was previously thought that 1% was an acceptable level, but recent experiments show that this level is not sufficient in practice in sea cages.

"Varying environmental conditions in the sea mean

that multiple factors affect the salmon's need for marine omega-3. An omega-3 level that is good enough for fish under ideal farming conditions may not be sufficient in more demanding environmental conditions," explains Nofima scientist Bente Ruyter.

Less robust

The content in current commercial feed varies, but all have over 1.6%. Nofima and NIFES have tested whether different levels of omega-3 affect fish health. These experiments showed that too little omega-3 can make salmon less robust and more prone to develop viral diseases.

The researchers know that the composition of the fats in the diet affects the distribution of fat in salmon, which can in turn affect the course of viral infections.

"There is still a fair degree of uncertainty, so we are not yet able to say exactly how little omega-3 is safe in commercial production of farmed salmon," says Ruyter.



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MORE INFO:
Read the
report





The Japanese love Norwegian mackerel and are picky about the colour of the fillets, according to studies conducted by scientist Themis Altintzoglou and his colleagues.



Mackerel with the right colour, please!

The colour of the fillet can mean make or break for Norwegian producers trying to enter the Japanese market with pre-processed mackerel fillets.

Most of Norway's mackerel is sold to Japan, where they eat 350,000 tonnes of mackerel a year. The Japanese buy whole mackerel from Norway and have it processed in Japan or China before it is delivered to retail outlets in Japan. Now the Norwegian mackerel industry wants to fillet the fish themselves so they can sell products with a higher profit margin. To succeed, it is essential that production is adapted to what the consumers want.

Nofima has therefore conducted studies where Japanese consumers were asked about various factors, such as appearance and packaging.

Colour of the fillet

"What's in the mackerel product package is much more important to Japanese consumers than what's on the package," says Themis Altintzoglou, who led the study.

"The Japanese want fresh fish and price is also decisive, but the most important factor is the colour of the fillet," he adds.

The ideal mackerel fillet should be uniformly pale, without any red hues. The fillet should not have any blood in it, the skin should be shiny and the meat should not be flaky.

So how can we ensure mackerel fillets are always the right colour? Stein Harris Olsen is researching how different fishing techniques and handling on board boats affect the quality of pelagic fish and has identified several factors that play a role.

Gently

"The basis for both the colour of the fillet and other quality criteria is laid during capture. Mackerel that spend a long time in the net become stressed, and blood is pumped into the muscles, giving the fillets a reddish hue and making them soggy," Olsen explains.

Mackerel are caught with large nets and are pumped from the net into a cargo tank using refrigerated seawater (RSW). The cold water knocks them out and they die quickly. In large catches, the fish spend a long time in the net before being pumped into the storage tank, resulting in exhaustion and in some cases injuries caused by stress and crowding. For Japanese consumers to get Norwegian mackerel fillets with the right colour, the mackerel must be pumped gently and be promptly transferred to cold RSW.



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Extruded grains and intestinal flora

Nofima scientists have investigated how intestinal flora – microbiota – are affected by unprocessed or extruded whole grains.

Recent research suggests that the composition of microbiota in our intestine is a key to good health, and it is well known that whole grains and fibre from grains reduce the risk of various lifestyle diseases, such as cardiovascular disease and diabetes. Our scientists wanted to find out whether it matters how the grain is processed. They carried out tests on young pigs because the pig's anatomy is very similar to that of humans.

Today grain is commonly extruded to preserve or improve the function of the fibre, at the same time as the structure of the grain can be altered. Extrusion is a process whereby wholegrain flour is heated to 120–140°C, while it is being kneaded, before being pressed through a die to obtain the desired shape, explains scientist Stefan Sahlstrøm.

Breakfast cereals such as Cheerios are an example of extruded grain.

Whole grains

"Our experiments shows that the pigs that were feed unprocessed whole grains, both barley and oats, had a richer

intestinal microbiota with more beneficial bacterial strains than the pigs that were feed extruded whole grains," says Nofima scientist Birgitte Moen.

The intestines of the pigs that had eaten unprocessed whole grains had a higher proportion of beneficial lactic acid bacteria such as bifidobacteria and lactobacilli, as well as more butyric acid. This is positive because butyric acid has an anti-inflammatory and anti-cancer effect in the intestine.

Healthy grain products

These results are very useful for food producers wanting to develop new, healthy grain products.

Nofima scientists have previously found that extrusion increases absorption of antioxidants, and that fermenting barley and oats with lactic acid bacteria increases the antioxidant activity significantly.



PHOTO: JON-ARE BERG-JACOBSEN@NOFIMA

Nofima scientists wanted to find out whether how grains are processed affect their health value.



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What is sludge made of?

Sludge is a growing problem in aquaculture. To be able to turn it into an asset – or handle it better – we need to know what it's made of.

Sludge from closed fish farming systems originates from feed. Ideally most of the feed should be eaten.

Scientists at Nofima have analysed sludge from three commercial hatcheries through an entire production year, resulting in precise knowledge about the content of the sludge, presented recently in two reports. Authorities, suppliers and fish farmers can use this knowledge as a basis for better management and use.

Energy, nitrogen and minerals

The analyses show that sludge has a high content of energy, nitrogen and minerals, such as phosphorus. Knowledge about the composition of sludge is essential if it is to be used as fertiliser and to produce biogas. The content of organic pollutants is low and does not constitute an environmental risk for use in fertiliser. By contrast, the zinc and cadmium levels in sludge are a challenge.

Sludge has a relatively high content of long-chain fatty acids, posing a challenge for biogas production, which can be resolved by co-processing with manure or other waste.

The researchers also created a model for calculating the amount of waste feed in sludge based on energy content. This model is particularly useful when trying to convert the sludge to biogas or fertiliser.

Minimising sludge production

As fish farming on land increases, the amount of sludge needs to be kept to a minimum. Research indicates two main areas where steps can be taken: the first is to prevent feed waste without compromising the growth and health of the fish. The second is to recover waste feed and fertiliser promptly in the pipe system without the particles disintegrating and before they absorb much water. This will make sludge recovery more efficient and reduce the water content in sludge.

With more sludge being produced, a solid effort must be made to find uses for it, in addition to minimising production. The best solution is to get more of the nutrients from the feed into the fish.



PHOTO: TERJE AAMODT © NOFIMA.

Less feed waste = less sludge. Nofima's model here is overfed more than salmon in Norwegian hatcheries.



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MORE INFO:
Read the
report



Sustainability index



The new sustainability index will describe the Norwegian aquaculture industry's positive and negative impacts.

Nofima and SINTEF are currently collating data on the Norwegian aquaculture industry with a view to presenting the industry's sustainability.

The Fishery and Aquaculture Industry Research Fund (FHF) has funded the development of a sustainability index for the Norwegian aquaculture industry, because sustainability is a key parameter in assessing the further growth in Norway and development of the industry. In Norway sustainability of the aquaculture industry is often associated with environmental sustainability, economic and social considerations are seldom included.

An overview

The sustainability index that is currently under development aims to provide a more balanced knowledge base. A web portal will be developed that can be used by anyone interested. The index will provide an overview of the state of the aquaculture industry on the basis of three criteria: environmental impact, economics and social ripple effects.

"The index will describe the industry's positive and negative impacts. There is already plenty of information available, which we now want to collate and compile with a view to

enabling identification of trends and developments in various fields," explains senior scientist Kine Mari Karlsen.

The index will show developments in relation to a number of parameters such as sea lice prevalence, number of escapes, employment figures, production value and drug use. The sustainability index will not weight the various factors or assess whether the industry is sustainable or not – the purpose of the portal is simply to provide access to all the facts about the aquaculture industry.

Want to reach everyone

"The goal is to make it easier for decision-makers, politicians, the media and other interested parties to access good, balanced information about the aquaculture industry. But we want to reach everyone who is interested in the aquaculture industry," says senior scientist Roy Robertsen.

The project was started in June 2016, and the scientists are now in the process of gathering the available information.



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From insight to impact

Nofima has published a book promoting and describing innovation in Norwegian food production, with examples of innovation in practice.

“The examples are based on innovations that Nofima has been involved in in one way or another, meaning we have good first-hand knowledge of the cases,” says senior scientist Einar Risvik.

Nofima’s involvement strategy

Relationship building usually starts out small, and as the level of trust increases, good ideas sprout and with time grow into major projects. For several of the companies that have accompanied Nofima into the world of research, it all began with a visit from a specialist. The next step was to become part of a network, before eventually taking part in national or international research projects. Nofima’s strategy is to facilitate this journey.

The authors describe underlying conditions that may affect innovation, and examples of trends in society are coupled with innovation theory.

The goal is to create an understanding of the diversity of and opportunities for innovation. The examples are intended to provide useful insights and inspiration for future innovation work.

Innovations can also arise in a supranational perspective. New Nordic Food is such an example.

Taking New Nordic Food as starting point, the authors describe the political and cultural frameworks and explain through examples how an overarching innovative concept can spark different types of innovation.

Less focus on price

Many of the examples in the book illustrate an innovation strategy that fits a high-cost country like Norway, i.e. innovations that emphasise perceived quality and consumer needs rather than price.

“For knowledge to add value, there are many stages you have to go through. Although it is not always easy to open to new ways of thinking, innovation is like a muscle that needs training. The more we do it, the better we become”, says senior scientist Antje Gonera.

“In the end, good innovations add value to businesses and society”.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Kasper Christensen, Antje Gonera and Stine Alm Hersleth have together with Einar Risvik, written the book about innovation.



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Norwegian research sparks green industry

Nofima's painstaking urchin research may end up as a successful Japanese business venture.

For two decades, scientists in Tromsø and Bergen have been studying sea urchins and feed for an innovative business venture. Now the Japanese are interested in this research too, as it may help them build up the sea urchin industry and save the endangered Japanese kelp forests.

Breakthrough

The breakthrough came as a result of Nofima's collaboration with the Norwegian investment company Kaston, which recognised that the research done in Norway could be useful in Japan, where the kelp forests off the coast had been devastated in the 2011 tsunami, and sea urchins are in the process of overgrazing the little that remains. The business concept involves harvesting sea urchins, putting them in specially designed boxes and feeding them so that they have a high roe content and thus high sales value. In less than one year, the kelp forests will recover, creating a habitat for other marine species.

To achieve this, high-quality feed had to be developed that ensures that the sea urchins grow well and produce tasty roe of the right colour. The concept and feed were tested on Japanese sea urchins with excellent results and a Japanese feed company was put in contact with Nofima.

Unique recipe

With the participation of Kaston and Innovation Norway, a licence agreement was signed in 2016, granting the Japanese company Nosan the right to produce and sell sea urchin feed, based on a unique recipe and production method developed by Nofima in Bergen. Representatives from Nosan have undergone training in Nofima's production hall in Bergen. Kaston negotiated and signed the agreement, operating under a licence from Nofima to commercialise this research.

Svend Haakon Kristensen, regional director for Asia at Innovation Norway, would like to see more such innovation projects.

"This project is of great symbolic value as an example of the direction that Norway's new special position is taking, how we can earn more money from the oceans, and the commercialisation of research," says Kristensen.



PHOTO: © NOFIMA



PHOTO: HELGE SKODVIN © NOFIMA

"It is the best feeling when research directly benefits the business community. There's nothing better," said scientist Tor Andreas Samuelsen when he shared the business secret with Nosan.



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Currency devaluation is good news

The lower exchange rate for the Norwegian krone in recent years has boosted the international competitiveness of the Norwegian seafood industry.

Scientists at Nofima have developed an index to measure the competitiveness of seafood prices based on the exchange rate, visualising the impact of fluctuations in the exchange rate on the competitive situation in the seafood industry.

With high production volumes and a relatively small domestic market, the Norwegian seafood industry is dependent on selling most of its products abroad. Since Norway's economy is small and heavily dependent on oil, the Norwegian krone (NOK) fluctuates widely.

Of the NOK 22.4 billion increase in the export value of all seafood from 2012 to 2015, NOK 14.1 billion is related to the lower exchange rate. The remaining growth of NOK 9.3 billion can be attributed to changes in volumes, prices and the product mix exported.

Other countries

"New export records have been set in recent years. However, we think it is problematic to use export value as a performance indicator, especially for whitefish and the pelagic sector. Export value, measured in Norwegian kroner, is a very imprecise measure of performance," says scientist Thomas Nyrud.



PHOTO: AUDUN IVERSEN © NOFIMA

Thomas Nyrud is one of the scientists who developed the seafood competitiveness index.

Currency fluctuations have affected the competitiveness of seafood from other countries too, such as Iceland in the whitefish market, and Chile, Ireland and Scotland for salmon. Norway has improved its competitive position vis-à-vis Iceland and Scotland & Ireland in particular as a result of the weak krone in recent years.

The seafood sector is more exposed to turbulence in the foreign exchange markets than the rest of the Norwegian export industry. This is because most of the international trade is done in the four major currencies (euro, US dollar, British pound and Japanese yen), while the other Norwegian export industries are generally exposed to a slightly broader portfolio of currencies.

Profitability and currency

The scientists have studied profitability in the fishing industry from 1993 to the present day and found that exchange rate fluctuations are an important factor in all the years with the best and worst results. For example, within whitefish we find that of the five most profitable and the five least profitable years in the last 20 years, the result in seven of the years coincided with major currency fluctuations.



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Read the
report



Selling ugly apples

Would you buy or eat a bruised apple? To reduce food waste we need to start eating food with a few cosmetic blemishes.

Scientists from several European research institutes have looked at what it takes to get consumers to choose non-optimal food items.

"It's worth noting that virtually all non-optimal food can be sold if consumers feel they are getting a big enough discount," says scientist Valérie Lengard Almlí, Nofima's representative in the EU project COSUS, which is being coordinated by Marije Oostindjer at the Norwegian University of Life Sciences (NMBU).

Over 4,000 northern European consumers

Using online surveys, scientists have charted what it takes to get people to choose sub-standard food items. They asked 4,214 consumers from five northern European countries about their choices when shopping and at home. Consumers are less picky at home.

The scientists also gathered other data about the consumers – demographic details and about their values. The survey found that consumers who believe food waste is a serious

problem were more likely to choose non-optimal foods, as were consumers who shop frequently and cook.

The extent to which consumers choose sub-optimal food items depends on what is wrong with the product. Curved cucumbers, damaged packaging and yoghurt with today's best-by date are relatively likely to be bought. Consumers are less likely to choose bruised apples and broken biscuits.

Bruised apples need the biggest discount

Wonky cucumbers and dented juice cartons do not require large discounts to sell; packets with a few broken biscuits and milk and yoghurt with the same-day sell-by date require a certain discount. But it is bruised apples that need the greatest discount to trigger sales and which are most likely to be thrown away in homes.

"Our findings show there is sales potential for non-optimal foods, especially to cooking enthusiasts and environmentally aware consumers. This may help reduce food waste by food producers and in shops," concludes Valérie Lengard Almlí.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Keen cooks and environmentally conscious consumers are easiest to convince about the importance of choosing less-than-perfect food items.



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Low omega-3 results in pale salmon

Scientists are studying the consequences of low intake of marine omega-3 throughout the entire salmon life cycle. One effect they have identified is paler fillets.



PHOTO: TERJE AAMODT © NOFIMA

Scientist Trine Ytrestøyl wants to find out more about the correlation between omega-3, stress and the colour of salmon.

"One reason we are studying this is that we need knowledge about the consequences for the health of the fish and quality of the fillet of further lowering the amount of marine omega-3 in salmon feed," says project manager Trine Ytrestøyl, a scientist at Nofima.

She and her colleagues have been conducting experiments with low intake of omega-3 throughout the entire salmon life cycle. Salmon weighing 40 g were fed 14 different diets until they reached 400 g. From 400 g to 3.5 kg, groups of salmon were given feed with a low content of marine omega-3 (0% and 1%), and then compared with salmon fed with 2.2% omega-3, which is the current level in commercial feed. When the fish reached approximately 1 kg, they were moved from onshore facilities to sea pens. Handling and transport were stressful for the fish. Three findings were especially interesting:

All groups of salmon grew satisfactorily, regardless of the omega-3 level in the feed.

Paler

Fewer of the salmon that had been fed with 0% and 1% omega-3 in their feed survived the experimental period than the salmon with 2.2% omega-3 feed.

The salmon fed with 0% and 1% omega-3 deposited less astaxanthin, which is a pigment and antioxidant. In other words, farmed salmon that consume less marine omega-3 are paler. This was also supported by genetic findings. Nofima scientist Aleksei Krasnov studies gene expression in salmon and has found a correlation between the body's conversion of astaxanthin and the amount of omega-3 in the diet.

Digging deeper

While the use of astaxanthin in salmon feed has increased, the amount retained in the musculature of Norwegian farmed salmon has declined in recent years. This is both inefficient and poses a quality problem, and Nofima scientists are continuing their work to find a solution in a new project.

"We do not yet know how stress affects the colour of the fillet. However, our hypothesis is that when salmon have a low level of marine omega-3 in their diet, they consume more of the stored antioxidant astaxanthin when exposed to stress. We believe this explains the paler fillet colour," says Ytrestøyl.



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PHOTO: BJØRN TORE FORBERG © NOFIMA

More and more wild-caught cod are being stored alive in pens before delivery. "The quota bonus system from 2013 appears to be having its intended effect," says scientist Øystein Hermansen

Record-high live storage

More and more cod are being held in live storage in Norway. In 2016, some 6,500 tonnes of cod were caught.

"The quota bonus system definitely seems to be working as intended," says scientist Øystein Hermansen.

There was a marked increase in the amount of live-stored cod in 2016, up from 6,000 tons in 2015, and a huge increase from 2013, when just under 2,000 tonnes of cod were delivered for live storage.

The quota bonus system, introduced in 2013, basically means that only half of the catch that is delivered to live storage is deducted from the quota. In theory this means that fishermen can catch twice as many fish. This is not quite the case in practice, however, since some of the fish are not viable after capture.

Cod are normally kept in a pen for 8–12 weeks, and both the producers and the scientists are gradually gaining experience of storage of wild-caught cod and the market opportunities this affords.

More experience

"Live storage is still in the research stage, and we need someone to dare to be the first and gain experience so that it is possible to make sound decisions in the long term. At present, for example, we do not know how profitable this

method really is," the scientist explains.

The producers are seeking to exploit multiple sources to increase the value and make up for the slightly higher costs.

"Having fish available beyond the relatively short fishing season makes it possible to exploit rising prices as the supply of fish falls. In addition, because live storage ensures higher quality fish, more of the fish can be sold in the best-paying markets," Hermansen adds.

He also points out how uncertainties in the supply of fish make it difficult to enter into long-term agreements with supermarket chains and other sales channels. With a live stock in storage, much of this uncertainty is removed.

12 weeks

Today, most producers are only allowed to store live fish for up to 12 weeks. A softening of the regulations means that it is now relatively easy for producers to get permission to store fish for longer.

Originally, the quota bonus scheme was only supposed to run until the end of 2017, but now it is being extended, albeit not indefinitely.



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Cod lasts longer with CO₂

An ingenious little pad that gently emits CO₂, can extend the shelf life of a package of fresh cod by up to four days.

“This could play a huge role in reducing food waste,” says Nofima researcher Anlaug Ådland Hansen.

Nofima has developed this tiny, flat piece of revolutionary technology, known as a CO₂ emitter, with funding from the Research Council of Norway and others.

CO₂ emitter tailored to each raw product

Perishable food packets already contain a small pad under the food, which absorbs moisture. However, that is all it does. By replacing the moisture-absorbing pad with a CO₂ emitter, the shelf life of the product is also extended. When the emitter comes into contact with moisture from the food, it emits CO₂, which inhibits bacterial growth, thereby extending the expiration date.

However, it is not quite as simple as it sounds: the CO₂ emitter has to be precisely adapted to the individual product and its moisture content and weight. In addition, hygienic handling before the product is packaged is essential.

Tests Nofima has conducted show that the shelf life of vacuum-packed cod fillet can be seven days. Inclusion of a CO₂ emitter increases the shelf life of vacuum-packed cod by two days, i.e. to nine days. This is the first time a CO₂ emitter has been tested in vacuum packs of cod.

Extended shelf life

Normal shelf life for the same cod fillet in packaging with a modified atmosphere (MAP) is up to nine days. If a CO₂ emitter is included in MAP packs of cod, shelf life increases by up to four days, i.e. a total of 13 days. The CO₂ emitter tests with cod were conducted at a temperature of 2°C.

“The CO₂ emitter is based on fairly new technology that is already in use. Our tests show that the emitters can be used in a very wide number of applications,” says Anlaug Ådland Hansen, while nevertheless stressing that although CO₂ emitters help extend shelf life, it is the initial level of bacteria in the fillet that ultimately determines how long it will maintain the required quality.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

The method requires detailed knowledge about the properties of the cod fillet, because the CO₂ emitter has to be adapted to the product to ensure optimal shelf life.



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Salmon puberty gene discovered

Nofima scientists have helped identify the salmon maturation gene – a major international breakthrough with major potential for farming.

The gene explains 39% of the variation for when salmon reach sexual maturation. This is uncommon, as sexual maturation is thought to usually be controlled by a large number of genes.

The team found that in a specific area of the gene, there are two variants that determine whether a salmon returns to the river to spawn as a small or large fish. Salmon that have two copies of the “small” gene variant will almost certainly become sexually mature while still relatively small. Salmon with two copies of the “large” gene will almost certainly not reach maturation until they have grown larger.

The right combination

“However, what is unique about this discovery is that for salmon that have one of each variant, gender determines when the fish will mature, and thus how big it will be. There is very little prior research showing that gender plays a role in how a gene is expressed,” says Nofima scientist Celeste Jacq, one of the authors of the article published in Nature.

This research will be very useful in the management of wild salmon stocks and for breeding companies.

“Breeding companies can control the prevalence of these gene variants in their broodstock, since the markers of the maturation gene make it possible to select the desired variant. This knowledge is freely available through the publication in Nature,” says Jacq.

Premature sexual maturation

Until now, breeding companies have only known when a fish will reach sexual maturity after it has occurred. Now, with the marker for this gene, salmon with early sexual maturation can be identified by genetic testing at the fry stage and be removed from the population. In this way, fish that are going to mature early will not be reared as potential broodstock.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Celeste Jacq helped find the maturation gene using DNA and growth patterns in fish scales from 1,500 salmon.

Some breeding companies have already begun removing suspected early maturing fish based on this finding, to prevent the fish they set out to sea reaching sexual maturity prematurely.



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Scottish partners

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Looking into fish

Using a hyperspectral camera, scientists can tell what lies beneath the skin of a cod – without resorting to a knife.

Scientists have previously used this technology to look for nematodes and are now developing monitoring methods for further quality parameters – for example blood content and freshness – simply by taking a picture of the fish.

“This is of great interest to players who deliver and receive fresh fish. We are working to make it possible in the future to examine all fish as they are landed,” says scientist Karsten Heia.

216 channels

Normal colour photos are composed of three colour channels with red, green and blue light, but a specially designed camera allows pictures across 216 channels. The camera can also detect visible and infra-red light. Combined, this opens up a spectrum of different analyses – as long as you know what you are looking for. The process is called imaging spectroscopy.

“Using all the information that our devices provide, and with the right algorithms, we can now see inside the fish in new ways,” says Heia.

In time he hopes the research will find commercial application.

Spectroscopy can also be used on red fish. Some producers of smoked salmon purchase up to 20% more salmon than they need to compensate for fish that during filleting proves to require trimming for blood and melanin spots. Avoiding this will save them substantial amounts of money.

Shelf life

Assessing how long a fish will last using spectroscopy is a real possibility in the future.

“It is fully possible, if the players are on board. During storage, proteins in the blood change. Blood oxidises, and the composition of information we get from the images can provide retailers with information on how long the fish can be expected to stay fresh, with an accuracy of +/- one day,” says Heia.

Nofima has recently launched two new priority areas. One, Spektek, is an internal Centre of Excellence that will deliver world-class research in spectroscopy and other analysis methods.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

“Sorting out unsuitable fish allows better exploitation of the capacity at filleting facilities,” says senior scientist Karsten Heia.



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FINANCED BY:
The Regional Research Fund North and
the Fishery and Aquaculture Industry
Research Fund (FHF).

PARTNERS:
Norway Seafoods, Cermaq

MORE INFO:
See film



Up one level for six species

European fish breeders can now integrate tools and technologies developed in FISHBOOST into their breeding programmes.

The main goal of the EU supported project FISHBOOST is to advance selective breeding to the next level programs for the six main finfish species in European aquaculture. These species are Atlantic salmon, rainbow trout, gilthead seabream, European seabass, turbot and common carp.

In line with other factors such as improved fish nutrition and health, selective breeding is a way to improve aquaculture production. In European aquaculture, major improvements can be made by establishing new, and developing existing selective breeding programmes.

Half way in the Nofima coordinated project, a solid knowledge base has been established and tools and techniques have been developed by the 26 research and industry partners.

Results ready to use

An important goal is to enhance the innate protection against fish diseases in farmed species. Especially for this group of traits, FISHBOOST partners have developed genomics tools and techniques for improving breeding programmes. One example is RAD sequencing technology to genotype cheaply. Another example is methods to reduce genotyping costs for genomic selection, by pooling DNA from individuals with extreme phenotypes in the reference population. These re-



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Nofima scientist Anna Sonesson, thinks the tools and competence from FISHBOOST will have significant impact in European aquaculture.

sults may lead to wider scale implementation of genomics in aquaculture breeding programmes with the ultimate aim to reduce disease incidences.

Software tool

For production traits, tools have been developed to record fillet yield indirectly on live fish by recording morphological traits of fish.

Researchers at Nofima have developed software for fish breeders to manage inbreeding in the selection and mating steps in a breeding programme. Other software selects strains or individual fish in strains to form a base population for breeding.

Today, there are 37 breeding programmes in Europe for the main six finfish species. An economic assessment of breeding programmes in European aquaculture is underway.

FISHBOOST
The next level of aquaculture breeding



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FINANCED BY:
The seventh framework
programme of the
European Community.

PARTNERS:
14 partners in research, tech-
nology and development, 11
industry partners, and FEAP.

MORE INFO:
See Fish-
boost's
website



Is food packaging safe?

We take for granted that the food we eat is safe. But what about the packaging? Currently there are international harmonised regulations only for plastics.

Plastic, paper and cardboard, ink and glue are all common ingredients in food packaging. It is important that the food we buy and eat is prepackaged in terms of safety, shelf life and to reduce food wastage. But can substances in the packaging migrate to the food and have a negative impact on it? This is what a team of Nofima scientists are trying to find out through the joint research project KiM – Safe Packaging.

Still not in place

“The project’s goal is to investigate the scope of and problems related to the chemicals in food packaging in Norway. By generating new knowledge and developing new analysis methods for chemicals in food packaging, we can contribute to safe packaging and better food safety,” says project manager Isabell Lien.

It is very important for producers and consumers that the food is not contaminated by hazardous substances that migrate from the packaging materials. Today only migrants from plastics are harmonised and regulated in the EU; harmonised regulations for cardboard, inks and laminating adhesives are still not in place.

Nofima scientists are involved in the investigation of use of chemicals used, the regulations, substance lists and databases, as well as in developing methods for chemicals that currently lack analysis methods.

Encouraging results

The project will help the industry to avoid using substances that are not toxicologically evaluated or that will be present in the packaging in quantities that may pose a health hazard.

“Commercially, it will make Norwegian packaging industry more competitive towards imported packaging from low-cost countries that do not have the same focus on chemicals in packaging as in Europe,” says Lien.

27 packages for various food products have been investigated in this Innovation Project for the Industrial Sector run by Elopak Technology Center (ETC). And the results are encouraging:

“All the packaging investigated complies with the regulatory requirements – by a wide margin,” says Isabell Lien.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Through the joint research project KiM – Safe Packaging, Nofima scientists are investigating chemicals in food packaging.



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FINANCED BY:
The Research
Council of Norway

PARTNERS:
Elopak, Norner AS and
packaging manufacturers,
food producers and
wholesalers

Rapid freezing and thawing

To limit liquid loss cod should be frozen and thawed rapidly. Rapid thawing has a greater impact on quality than previously thought.

All fish, fresh or thawed, loses fluid during storage. Until recently we had limited knowledge about how freezing and thawing affects fluid loss, and thus the quality of frozen fish. Many fishing vessels deliver their catch frozen, and the fish are thawed on land for processing. Nofima researches have conducted tests to study how the rate of freezing and defrosting influence liquid loss in cod.

Twice-frozen

Cod fillets were vacuum-packed and frozen, using two different methods of freezing: rapid freezing in circulating air at -40°C and slow freezing without air circulation at -20°C . The fish were then thawed at 4°C , either rapidly in circulating water, or slowly in air.

The researcher also studied the effect of double freezing. Fillets were frozen and thawed again as described above. Consequently, the scientists had four different groups of fish, and 16 combinations of freezing and thawing for the double frozen fish. The results are clear:

"We found a major difference in fluid loss between the various combinations of freezing and defrosting fish. Rate is a clearly decisive factor. For a twice-frozen product, only two of the 16 combinations significantly limited drip loss, and the final defrosting is the most important," says scientist Svein Kristian Stormo.



ILLUSTRATION: ODDVAR DAHL © NOFIMA

Rapid defrosting in water

Fluid loss in fish that was frozen once ranged between 4.3% and 10%. The best fillets were those that were frozen rapidly at -40°C and defrosted in circulating water. Speed has an even greater impact when the fish is frozen twice. But since it is the final defrosting that is decisive for the quality of the fillets, it is not necessarily the fish industry's fault if your cod dinner is a little dry.

"Many consumers are used to defrosting frozen food slowly in the fridge. Based on this research, we will now recommend rapid defrosting in water," says Stormo.



PHOTO: AUDUN IVERSEN © NOFIMA

Nofima scientists Svein Kristian Stormo and Torstein Skåra recommend rapid defrosting in water for frozen food.



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FINANCED BY:
Nofima

Less sugar, salt and fat

By reducing the sugar, salt and fat content of food while still retaining flavour and texture, Nofima can improve public health.

Obesity and diet-related diseases are on the rise in many parts of the world. This has led to a growing focus on how to improve the nutritional value of the food people eat. Nofima has therefore taken part in the major international research project, TeRiFiQ, with scientists and food producers in nine European countries.

Among the Norwegian food producers that participated in the project were the meat producer Leiv Vidar and the bakery Millba. The goal was less fat and salt in sausages and less fat and sugar in muffins – while ensuring the products tasted, looked and felt as good as before.

Important for product quality

“Sugar, salt and fat are important for taste, texture and shelf life. There is a huge amount of research work behind the results achieved,” says scientist Eva Veiseth-Kent, who headed the Norwegian part of the project.

In summary, the project worked on:

- Selection of raw materials
- Changes in processing
- Emulsions (mixtures of liquids that are normally immiscible)
- Suitable substitutes for salt and sugar



PHOTO: JON-ARE BERG-JACOBSEN ©NOFIMA

TeRiFiQ is making it possible to reduce the amount of salt, sugar and fat in more food, while retaining the familiar flavour.

Consumer acceptance

“There has also been a lot of work done on sensory aspects – how the products taste and feel when they are eaten,” says Eva Veiseth-Kent.

“Taste is important, and if consumers are going to like and recognise the product, you have to find ways to replace sugar, salt and fat without com-

promising taste, functionality and shelf life.”

Based on the results of TeRiFiQ, it will be possible to reduce the amount of salt, sugar and fat in several ready-made dishes and products such as cheese, meat and bakery products, while retaining the familiar flavour.



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FINANCED BY:
The seventh framework
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PARTNERS:
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partners from nine countries
in Europe

MORE INFO:
See Nofima's
website



Robust, hungry and right-sized



PHOTO: LARS ÅKE ANDERSEN © NOFIMA

Based on targeted, long-term breeding work, Nofima is breeding lumpfish with good health, steady growth and a big appetite for lice.

The ideal cleaner-fish must be in good health, be the right size and have a big appetite for salmon lice. Is this possible?

It is, according to scientist Panya Sae-Lim. Based on targeted, long-term breeding work, Nofima is breeding lumpfish with all the desired characteristics.

Happy fish

Lumpfish are common along the Norwegian coast and have a good appetite for one of the banes of Norwegian salmon farming: salmon lice. Traditionally, fish farms have used wild-caught lumpfish as cleaner-fish. However, salmon pens are very different to the lumpfish's natural habitat, resulting in a high mortality rate among cleaner-fish. Nofima's breeding programme has therefore focused on breeding a fish that will thrive and is also robust against the bacterial disease vibriosis.

"We use families that have steady growth as broodstock. Lumpfish develop cannibalistic tendencies if the individuals are of very different sizes," explains the scientist.

And since some lumpfish seem to be fonder of eating lice than others, it is clearly best to use the most voracious for breeding.

Benefits the industry

"We select broodfish from a population with natural genetic variations and breed using the individuals with the desired qualities. Breeding a healthy, robust fish that is adapted to the environment it is going to live in and has a particularly voracious appetite for salmon lice ensures fish welfare and benefits the aquaculture industry," says Panya Sae-Lim.

Fish farmers will be less dependent on wild fish and will have cleaner-fish with better survival rates and less variation in growth and thus size, meaning they will not need to be replaced so frequently.

The current tests involve 2,000 lumpfish from 68 families from the breeding station in Tromsø, and the results will be ready in early 2017.

"The research on lumpfish is continually evolving. We have not yet fully understood the genetic possibilities," says Panya Sae-Lim.



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Basic grant from the Research
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MOR INFO:
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website



Food to suit every palate

The number of people with chewing and swallowing difficulties is rising. Scientists, chefs and food producers want to ensure that they too can have attractive, tasty and nutritious food.

Some people struggle to chew or swallow food for a variety of reasons. Many of these are elderly, and the problems can often lead to malnutrition. Good, nutritious food is important for quality of life, helps prevent unnecessary health problems and ultimately saves society resources.

The special food these people need cannot be bought in shops, which is a problem for people with eating difficulties who live at home and who buy their own food. This group is predicted to grow significantly in coming years.

New meal concepts

Senior Scientist Jan Thomas Rosnes is working on creating new meal concepts that can alleviate the situation. In collaboration with research colleagues and chefs, he is investigating how food ought to be processed to achieve a texture that best suits individuals with eating difficulties.

In order to achieve the optimum consistency and texture for the different needs, so-called “consistency modifiers” are added to the food. The researchers are testing soya, bean starch and the algae product agar, among others.

“Aspects we are looking into include how different temperatures affect the colour of the food, fluid loss and nutritional content, and the shelf life of this food,” says Rosnes.

International experts disagree on how to define and measure texture levels for elderly people. The researchers are therefore working to identify the best indicators that can be used in research projects and in the development of equipment.

Pure, nutritious and attractive dishes

The knowledge produced will be used to create products from pure foods such as vegetables, fish, milk, grains, eggs and fruit, with a high natural content of protein and energy. The researchers are also looking at food with a high con-



PHOTOS: JON-ARE BERG-JACOBSEN © NOFIMA

Special food should look good and taste good, as well as being nutritious and easy to eat.

tent of one type of nutrient, for people who need greater amounts of this. However, the shape and colour of the food are also important.

“How the dishes look is very important. It is often said that ‘we eat with our eyes’. Attractive food is more appetising, which is particularly important for people who are undernourished or at risk of becoming so,” says Rosnes.



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FINANCED BY:
Regionalt forskningsfond
Vestlandet RFFVest

PARTNER:
The knowledge platform “Food
has not been provided until it has
been eaten” by Måltidets Hus AS.

MORE INFO:
See Nofima’s
website



Coastal coexistence

Can fisheries and the aquaculture industry share space along the coast?

Aquaculture and coastal fisheries are two major industries whose needs and interests sometimes conflict, especially when it comes to the effects of salmon farming on cod spawning and saithe eating excess feed from salmon pens. However, new research has found that the quality of saithe that eat salmon feed is not necessarily inferior.

"It is well documented that wild fish that eat excess feed grow bigger and fatter, and the quality of most of the saithe we have examined is good," says senior scientist Bjørn-Steinar Sæther.

Positive environmental effect

Attracting wild fish to fish farms may actually be positive since they can eat much of the surplus feed before it reaches the bottom, where it can have a negative effect on the benthic fauna. However, scientists do not have enough accurate data on feed loss and how much of this saithe manage to eat to be able to gauge this effect.

In addition, waste feed may lead to increases in local wild fish populations.

"Wild fish near fish farms often grow faster, as they eat energy-rich pellets. The increased energy reserves yield larger roe and more eggs – and thus may provide a basis for more offspring. We do not know enough about the quality of these eggs, but so far our studies have not found any negative effects," says the scientist.

Little difference

What about the quality of the saithe that eat salmon feed? Some people say that these fish are inedible, and some fishermen have reported poor quality of fish caught near fish farms.

The scientists fished using nets and jigs near fish farms at different times of the year over a period of three years. The results indicate that the quality of the fish they examined was generally good, although slightly inferior in the saithe that had eaten salmon feed.

"Our results do not support the claims that all saithe that eat salmon feed are ruined," says Bjørn-Steinar Sæther.



PHOTO: TOR EYENSEN © NOFIMA

Wild saithe that eat excess feed from fishfarms are larger and fatter than saithe that do not eat salmon feed and of generally good quality.



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The Fishery and Aquaculture
Industry Research Fund (FHF)

PARTNERS:
Norwegian Institute for Nature
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Marine Research



Helping local berry producers

Simmering pots in the pilot plant of vegetables give off the fragrance of raspberries, blueberries and strawberries, vanilla, cinnamon and cardamom.

Nofima's berry experts hold courses for local food producers in processing of fruits and berries. The producers can try out new recipes for juices, drinks, jams and jellies. They learn how different techniques affect flavour and texture, and how to retain most of the berries' goodness when they are increasing their producing volumes.

The participants have the opportunity to experiment with different spices and amounts of sugar. The courses consist of theoretical and practical sections, and they can use different equipment and machines and decide which best suit their own purposes.

"They learn to use pure pectin instead of Certo. Pectin is found naturally in many fruits and berries, and the amount you need varies according to the kind of berry," says Nofima scientist and course leader Berit Karoline Martinsen.

Utilizing surplus of fresh berries

Course participants include blackcurrant, strawberry and raspberry producers. Common to most is the goal of starting up

or further developing their own processing, either in collaboration with other farmers or alone.

Søndre Elton farm grows strawberries on the banks of Lake Mjøsa. Until now, Anette and Børre Vold have concentrated on selling fresh berries – to wholesalers and directly on the farm.

"At the end of the day there are always some berries left, and I want to learn the art of making juice and jams, to avoid having to sell yesterday's berries," explains Anette Løvlien Vold.

Annette and her husband are building a new barn on the farm, to house a freezer and their own production facilities. "It has been very helpful for me to learn about and see the different equipment in use, and not least to hear other people's experiences and recommendations. I now know which machines we should go for and how to get going with production," she says.

The government's local food initiative and the competence networks

The Norwegian government has a goal for sales of local food of NOK 10 billion in 2025. Sales are currently NOK 5 billion, up 8.8% from last year.

The focus on local food and local food producers is an important part of the government's efforts to create a basis for more future-oriented agricultural production throughout Norway. The competence networks for local food are an important tool to achieve this goal. Nofima manages the networks for southern and eastern Norway.

"I am very pleased with the Competence Network for Local Food's work to ensure that food producers get the knowledge they need to take the next step," says Minister of Agriculture and Food Jon Georg Dale.

Small food companies with up to 10 employees can receive help to succeed with development and value adding. Norway is divided into five competence hubs that arrange courses, seminars, networks, study tours, internships and visits, adapted to the companies' needs.

The county you live in determines which competence network you belong to. However, the services on offer are available to everyone regardless of where they live. In addition to the five regional competences hubs, Matmerk – The Norwegian Agricultural Quality System and Food Branding Foundation also offers the same target group assistance with market services. Innovation Norway is the national coordinator of the competence networks.

Processing knowledge to maintain freshness

Another producer that has benefited greatly from Nofima's expertise is the father and son team Jan and Ørjan Johnsen of Lyngnes Farm in Randaberg. They grow grapes and apples, which they process to make fresh unsweetened juices. They see a growing potential for locally produced juice based on healthy ingredients.

"Local processing of own-grown produce is essential for our business to be profitable," says Ørjan Johnsen. Through the Competence Networks' visit scheme and a Regional Innovation (VRI) project run by Rogaland County, Nofima scientists have helped them in their efforts to develop processing methods that take the best possible care of the fresh ingredients.

Raspberry beer and blueberry vinegar

"We're seeing an increase in the number of knowledge-intensive questions from local food producers. Many want



Course leaders Berit Karoline Martinsen and Kjersti Aaby, both from Nofima, preparing the juice press.



Nofima's sensory assessor Kristine Myhrer teaches local food producers the importance of assessing taste and other sensory characteristics.

PHOTOS: KJELL MERØK © NOFIMA

to create more complex products using their own produce, and they seek assistance with more ambitious processing methods such as fermentation," says Stine Alm Hersleth, project manager for the competence network for local food in eastern Norway.

It is highly satisfying for Nofima's experts to see more of the knowledge they generate through research projects directly benefiting local food producers. At the same time, contact with local producers enables the scientists to learn more about their research-based needs.

"There is great political willingness to invest in local food, and it is exciting to see that local food producers are becoming more adventurous and confident – and not least creating more added value," concludes the Minister of Agriculture and Food Jon Georg Dale.



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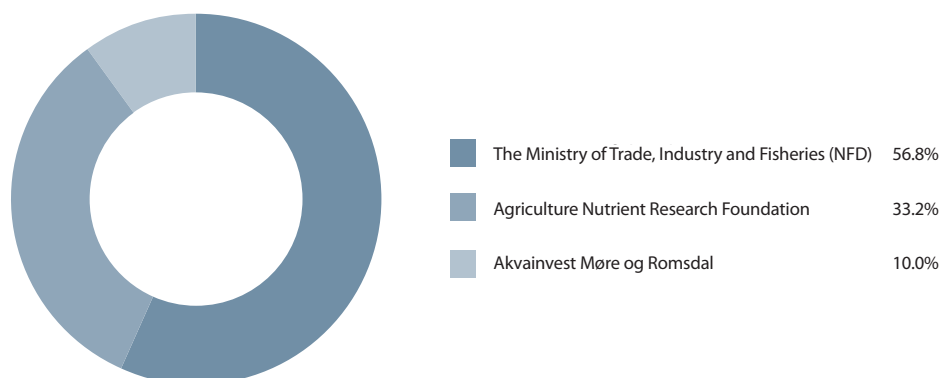
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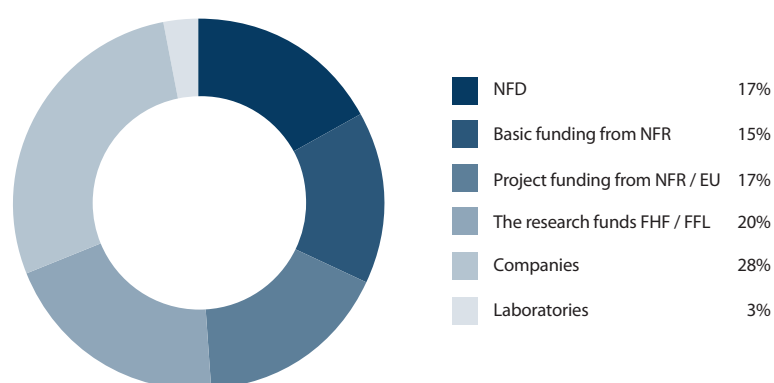
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Facts and figures

Structure



Funders



The following are our largest funding providers

RESEARCH COUNCIL OF NORWAY (NFR) 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 TRADE, INDUSTRY AND FISHERIES (NFD) is responsible for the fishery and aquaculture industry, fish health, fish welfare, seafood safety and quality and more.

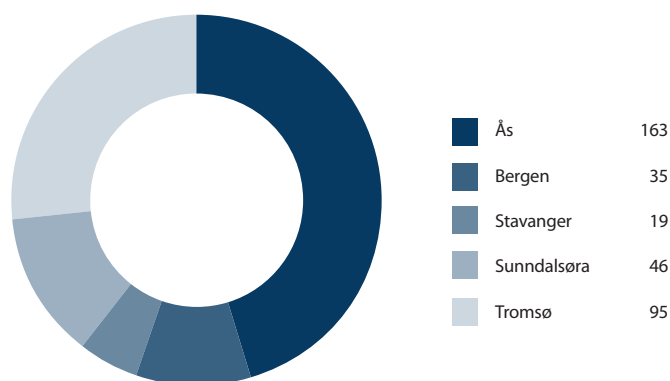
THE NORWEGIAN SEAFOOD RESEARCH FUND (FHF) shall create added value for the seafood industry through industry-oriented research and development. Financed through a levy on all seafood exports.

THE RESEARCH FUNDING FOR AGRICULTURE AND FOOD INDUSTRY (FJM)/AGRICULTURE NUTRIENT RESEARCH FOUNDATION (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.

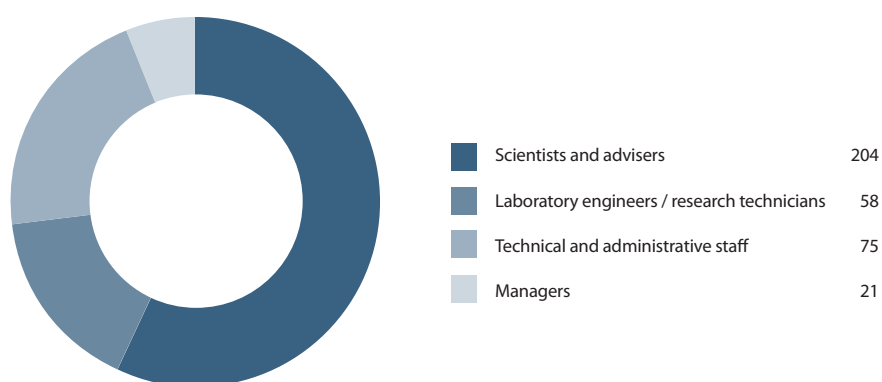
THE INDUSTRY – Nofima's R & D work is oriented primarily towards the aquaculture, fishery and food processing industries.

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

Geographic distribution of employees



Employees by function



This is Nofima

Nofima delivers research-based knowledge that improves the competitive strength of Norwegian food producers. With some 350 employees, of whom 150 have a PhD, we are one of Europe's leading food research institutes. The research work in Nofima is organised into three divisions.

Division Aquaculture

- Breeding and genetics
- Nutrition and feed technology
- Fish health
- Production biology

Acting Director Arne Mikal Arnesen

Division Fisheries, Industry and Market

- Seafood industry
- Processing technology
- Industrial economics and strategic management
- Consumer and market research

Director Magnar Pedersen

Division Food Science

- Breeding and genetics
- Nutrition and feed technology
- Fish health
- Production biology

Director Camilla Røsjø

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.



We know about food

We want to know our customers!

We have therefore set up an internship scheme
to bring us closer to our clients.

Nofima delivers research-based knowledge that improves the competitive strength of food-producing industries. Each year a handful of our scientists spend time out in the companies to get even better understanding of the business.

Innovative solutions must be implementable, otherwise they have no value.

Curious about Nofima's internship scheme?
Please contact one of our research directors:

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We know about food



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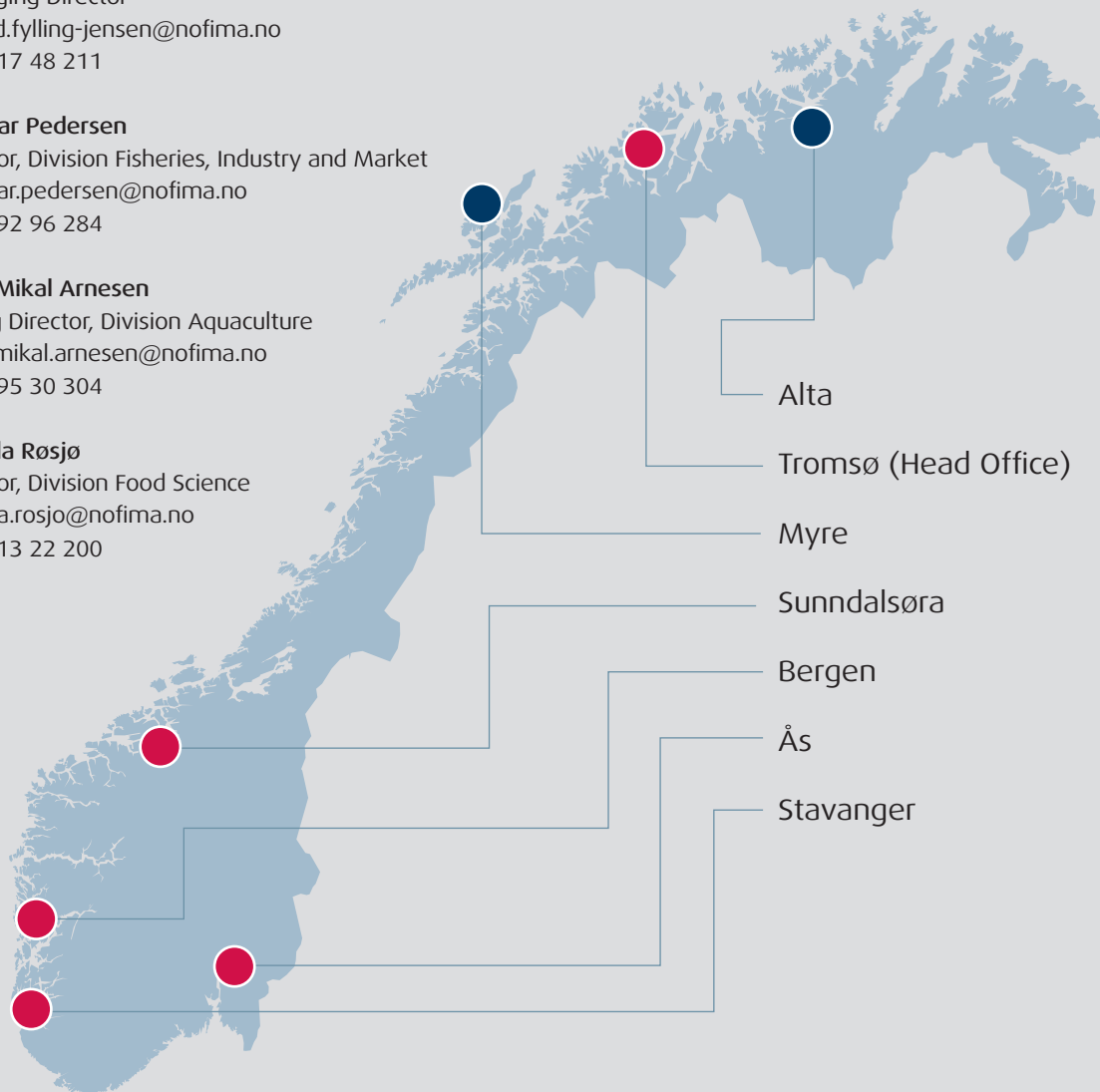
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