

Creating value

Project year 2017



25
examples
of useful
research

Strategic Research Initiative



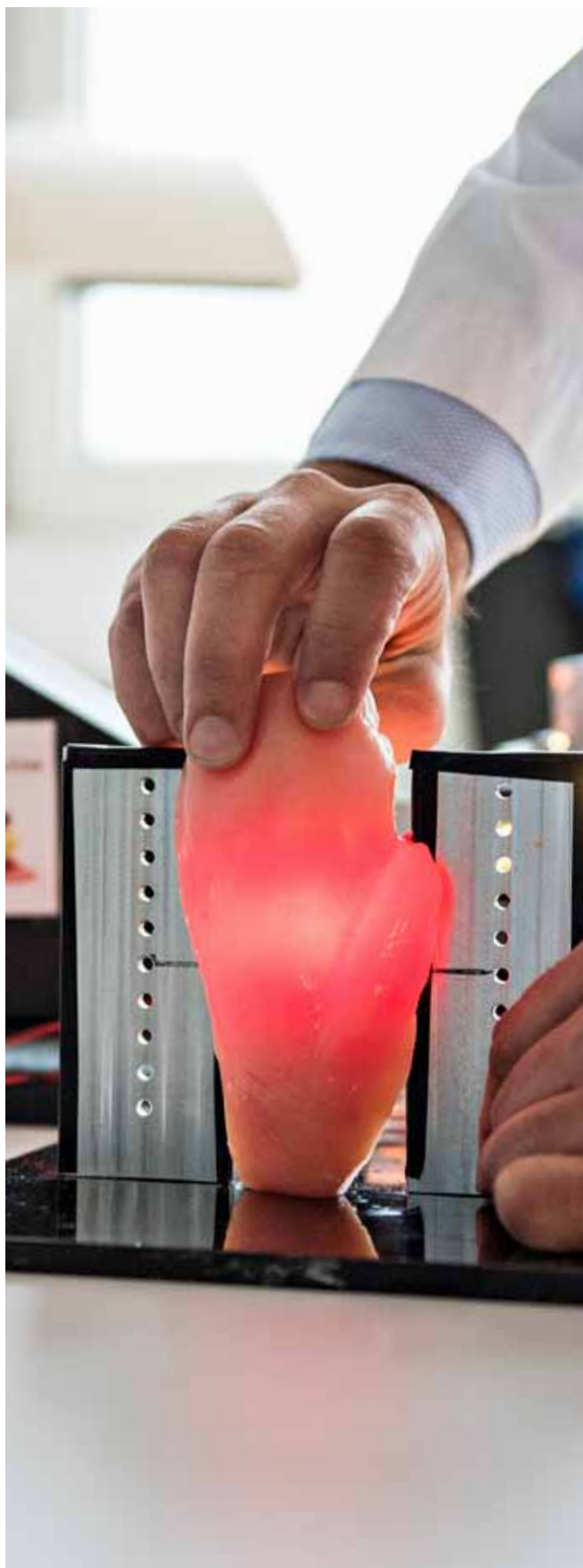
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Peptek – for tomorrow's protein production

Using modern, research-based processing technology and expertise, unused or left-over biomass ("residual raw materials") can be transformed into new, marketable products. Through the Strategic Research Initiative "Peptek", we work to establish a comprehensive approach and procedures for the treatment of residual raw materials from the food industry. By developing coordinated solutions for analysis and processing, we are building the foundation for the production of protein in the future.

Read more about the topic on page 11 and page 24.

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High scientific quality and great commercial potential

Dear reader

Welcome to this year's edition of the Nofima magazine *Creating value*, the seventh in the series. Each project year since 2011 we have presented a selection of our current research areas to showcase the breadth of our research and innovation activity. I hope you find the content interesting and that it demonstrates that research can be of high scientific quality and at the same time have great commercial potential.

Some of the research is more fundamental in nature, while other parts of our work are more closely related to practical needs of the industry. A common denominator in all Nofima's activities is that they shall contribute to increased value creation.

Fundamental research is absolutely necessary for Nofima to meet its goal of being at the forefront of research. We achieve this by spending a significant part of our basic government funding on research in areas that we predict will need research-based knowledge in the future. We also spend significant internal funds on major strategic research programmes and fund PhD students, further strengthening our research work in key areas.

It is gratifying to see the good progress being made in our two strategic research initiatives: Spectec (on spectroscopy and other rapid, non-destructive measurement methods) and Peptek (on the circular bioeconomy and exploitation of residual raw

materials). The topics for the long-term research activities have been chosen on the basis of the needs that we see the industry has and challenges they will need solutions for in the future.

To enhance Nofima's relevance, we have established a internship system whereby our employees can spend time working with industrial players along the entire value chain. This gives us good insight into current and future knowledge needs.

Nofima has also prepared an innovation strategy, based on the findings of a survey among our clients, the public funding system and other stakeholders. The goal of this strategy is to ensure that our research is implemented and that research-based knowledge is an important element in resolving some of the major challenges the business community will face in the future.

In this context, we need only refer to the United Nations' ambitious plans to achieve its 17 sustainability development goals, or the challenging actions to combat climate change that were adopted in the Paris Agreement at COP21. Nofima's strategy has these international agreements as a backdrop as we look to the future.

As we head into 2018, Nofima is a well-run institute that delivers high-quality research of great relevance to industry, as is proven by this edition of *Creating value*.

Happy reading!



Øyvind Fylling-Jensen
Managing Director



Sterilisation breakthrough for farmed salmon

After ten years of research, Nofima has finally cracked the code on how fish farmers can produce sterile salmon – without genetic manipulation.

A key protein is modified in the egg stage, so the salmon do not develop reproductive cells.

There are currently over 2,000 sterile salmon swimming round at the aquaculture station in Tromsø. Senior scientist Helge Tveiten is very pleased, since all the signs indicate that they are just as happy as any other salmon. Scientists have found a method that only affects the fish's ability to reproduce, and nothing else. The biggest fish here are now one year old and weigh around 300 grams.

"The salmon we have bred don't develop reproductive cells and will never mature sexually. The females develop a very small roe pouch, but eggs don't form. Male fish develop seemingly normal sexual organs, but they don't have sperm cells," Tveiten explains.

Based on the studies carried out so far, the sterile fish have the same appearance and properties as fertile farmed salmon.

Faith in the idea

Tveiten encountered some scepticism in other research circles when he presented this sterilisation method, and Nofima has therefore used substantial own funds in this project.

"In purely biological terms, I knew early on that this method was viable. Research on zebra fish had identified a small number of genes that are decisive for the development of reproductive cells. The removal of one or more of these gene products resulted in a fish without reproductive cells, but which otherwise developed normally. There was no reason a similar approach could not be used on salmon. In practice, we don't touch the genes; rather we modify a protein required for the fish to develop reproductive cells," the senior scientist explains.

With time, several partners have recognised that this sterilisation method may resolve many of the challenges facing the aquaculture industry.

Environmental protection and animal welfare

Tveiten's important findings are excellent news for many circles. There are numerous good reasons for producing sterile farmed fish, including environmental protection and animal welfare.

If farmed salmon are sterile, escapees will not interbreed with wild salmon, impairing the wild salmon population – a scenario feared by many today. Additionally, fish farmers would prefer to prevent salmon from maturing, as they become significantly more susceptible to disease and have greater problems maintaining the water-salt balance in the sea.

"The quality of the fillets also deteriorates when salmon mature, resulting in a lower value product," the scientist adds.

Few alternatives

Tveiten and co.'s work led to the establishment of the research project SalmoSterile, the goal of which is to find a simple, safe way to sterilise farmed fish. Now that the method is here, all that remains is to rationalise it, so that the industry can start processing the eggs on a large scale.

Today, salmon are sterilised using triploidisation, where the fish are given a second set of chromosomes. Triploid salmon, however, are inferior to normal fertile salmon, and this method is not used very widely. It is therefore essential, according to Tveiten, to develop better, more targeted sterilisation methods.

"We will have to monitor these fish over time, but there is nothing to indicate that they will mature or have a migratory urge to spawn. Of course, thorough investigations must be conducted to find out whether escaped sterile salmon will move up rivers. This will require more research, but as it stands, such a scenario is very unlikely," Tveiten believes.

The next phase is to develop the method for the industry, in collaboration with industrial actors and the salmon industry.



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PHOTOS: OLE ÅSHEIM © NOFIMA



Studies show that the sterile fish (the four at the back) have the same appearance and properties as fertile farmed salmon (the two closest to the camera).

Helge Tveiten has spent ten years developing the method that allows breeders to produce sterile salmon without genetic manipulation.

Getting to grips with crab meat

Determining how much meat is in crab legs the old-fashioned way is time consuming and inaccurate.

We have developed a better way of measuring meat content.

The amount of meat in a king crab's legs varies according to where it was caught and the season. To date, it has been hard to know which crabs have the highest meat content.

"Crabs are currently sorted manually – workers squeeze one or several of the crab's legs to guess the meat content. This is time-consuming and not very accurate," says Jens Petter Wold, a senior scientist at Nofima.

New method

Companies that make products out of king crab have long needed a way to reliably measure meat content and sort the raw materials.

"Rapid measurement will revolutionise sorting by meat content and setting of prices between fishermen and processing companies," says Grete Lorentzen, a senior scientist at Nofima.

She is heading the Finnkrabbe research project, where

businesses and scientists are working together to develop new, improved methods for processing snow crab and king crab. A main goal is to develop a rapid, non-destructive and accurate means of measuring meat content in fresh and live crabs' legs. Using near infrared light (NIR) we can "see" inside the crab legs without harming them.

Promising

So far, the project looks very promising.

"We have tested various instruments, and achieved very good results with a NIR instrument that was originally developed to measure the fat content in whole salmon. Light is shone into a crab leg, and we measure the light that is reflected back, providing us with information about the water, fat and protein content. The measurement takes one second and will hopefully be of great benefit to the industry," says Grete Lorentzen.



PHOTO: © NOFIMA

Jens Petter Wold do not need to squeeze the crab's legs to guess the meat content. Now the light settles the matter – rapidly and painlessly.

Large-scale industrial production

The team is now testing different methods to find the one best suited to large-scale industrial production.

"The measuring method that works best today requires the crab legs to be held up to a sensor manually. Ideally though, the industry would like a system that can be installed over a conveyor belt and automatically scan the crab legs that pass beneath. We hope to get there during the project period," says Jens Petter Wold.

The scientists are working with Storbukt Fiskeindustri in Honningsvåg and Arctic Catch in Vardø – both significant players in the Norwegian crab industry. In addition to the meat measuring instrument, the project is also working on developing humane, ethical methods of stunning and killing snow and king crab. As well as ensuring animal welfare, it will also enable quicker, easier crab processing. Methods are also being developed to improve bleeding, cooking, chilling and freezing.

The scientists believe that an instrument that can measure meat content will have applications far beyond this project.

"Live storage of king crab, for example, which we expect to become increasingly common, with feeding to increase the meat content. This kind of instrument will be very useful to know when feeding can be stopped. It can also be used in live storage without access to food, to know how long crabs can be stored before the meat content is affected – which is priceless information," says Grete Lorentzen.

The project is also looking at whether the measuring technique developed for king crab can be used to measure the meat content of the slightly smaller snow crab.



PHOTO: © NOFIMA

Using near infrared light (NIR) Nofima scientists can "see" inside the crab legs without harming them.

Nofima – Strategic Research Initiatives

With a view to providing businesses with the expertise they need to deliver top-quality products, Nofima is developing world-class research in selected areas. Spectroscopy is one such area, and through the Spectec project, a Strategic Research Initiative headed by Jens Petter Wold, scientists are working to improve and develop new and better rapid measuring methods using light.



PHOTO: © NOFIMA

During trials, real content in crab legs is compared to what the light indicated.



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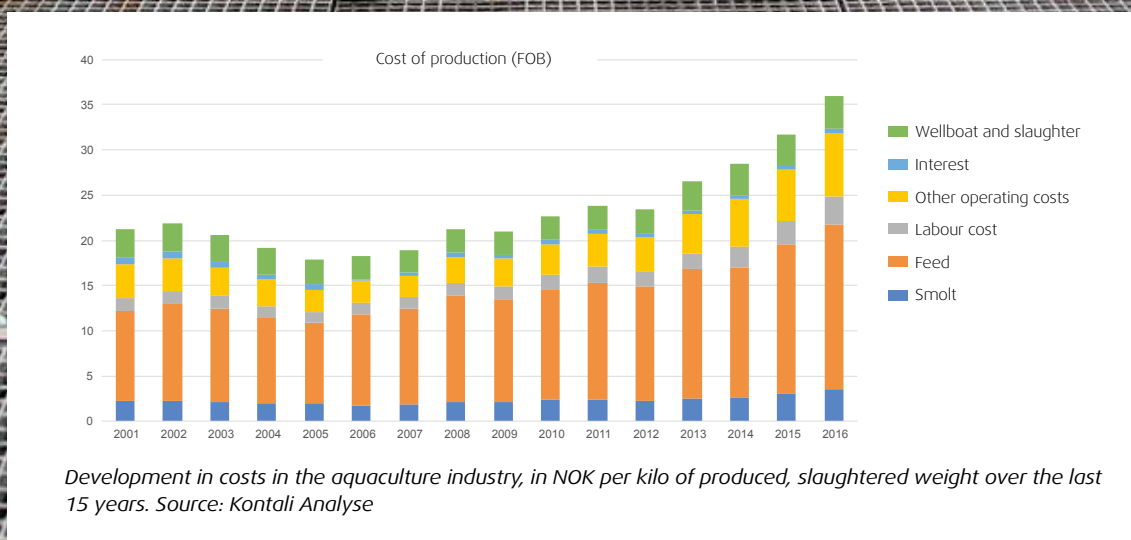


PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Scientists Øystein Hermansen (left) and Audun Iversen have analysed costs in the aquaculture industry for several years to identify the drivers.

High lice costs, rising feed prices – and expensive land-based facilities

The costs of fighting sea lice may have passed the peak.

Expensive closed facilities are nevertheless more relevant than ever.

From 2012 to 2016 production costs in the aquaculture industry rose some 50%. The costs of fighting sea lice have received by far the most attention. However, the main reason for the increased costs was rising fish feed prices.

“The challenges linked to sea lice have a huge impact on the industry’s reputation and opportunities for continued growth – plus there is very little fish farmers can do about rising feed prices,” says Nofima scientist Audun Iversen.

Together with his colleague Øystein Hermansen, he has analysed costs in the aquaculture industry over several years to identify the drivers.

The largest single increase in production costs is rising feed costs, up from NOK 14 a kilo of slaughtered Atlantic salmon in 2014 to NOK 18 in 2016. However, feed’s share of the total costs has still declined from 54% to 50%, due to larger relative increases in other costs.

NOK 4.5 billion per year

“The total cost of sea lice is around NOK 4.5 billion per year, not taking the cost of reduced growth rate into account. Nor have the challenges sea lice represent for the industry’s reputation and opportunities for further growth been taken into account,” says Audun Iversen.

The cost of fighting sea lice can be broken down thus:

- Cleaner fish, such as lumpfish and wrasse, cost a little over NOK 1 per kilo of produced salmon – a total of almost NOK 1 billion
- Treating salmon for lice costs close to 2 billion NOK
- In addition there is the economic effect of starvation prior to treatment, which we have estimated to around 700 million NOK

From 2015 to 2016, however, there was a small decrease in the cost of fighting lice.

“It looks like we may have passed the peak for costs, although this depends on how much more treatment is still required,” says Øystein Hermansen.

Can closed farming be profitable?

In light of these lice costs, there is growing interest in closed containment facilities.

In financial terms, the sea pen system we have used since the 1970s is quite unique, with very low costs for keeping the salmon in one place. A large facility costs around NOK 50 million, including all the pens, feed barges, working boats, moorings and other equipment. This provides a fish farming capacity of 1 million m³, i.e. an investment cost of NOK 50 per cubic metre of farming volume.

Farming in closed facilities requires a significantly larger investment. New closed containment facilities in the sea cost around NOK 5,000 per m³ of farming volume, while land-based facilities can cost more than NOK 20,000.

“This does not mean that closed facilities cannot be profitable, but the way fish farming is done must be changed. In short: operations must be much more intensive,” says Audun Iversen.

Ideal timing

Among other things, stock density must be much higher than it is today, and good systems must be found to make full use of the available capacity.

“This will require new systems to ensure fish growth and welfare,” the scientist explains.

There are still many unresolved issues related to both biology and economics in closed facilities, and in order for it to be profitable to produce large salmon in closed facilities, more knowledge is needed.

“As with all new technology also, closed fish farms need time to mature to become financially efficient. In light of the prices we have seen in recent years, however, the time is right to succeed with this type of technology,” says Audun Iversen.



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"Collagen from fish bones is a valuable resource that we believe the industry can access," says scientist Sissel Albrektsen.

Rich pickings from cod bones

If the fishing industry can extract the collagen from fish bones, it could earn millions. Scientists have managed this in the lab.

Now they are trying to do it industrially.

Nofima has received funding for this work from the Research Council of Norway's FORNY2020 programme to ensure results from publicly funded research are brought to the market.

Each year 160,000 tonnes of cod trimmings are thrown away, because there is no financial incentive for fishermen to keep them.

"The trimmings contain a lot of bones. The nutrients in bones are difficult to digest, meaning they are currently underutilized and often discarded," says scientist Sissel Albrektsen.

Fish bones have a high collagen content. This protein is used in face creams and dietary supplements and has potential as a health-promoting ingredient in salmon feed.

New method

Collagen is extracted from fish bones after demineralisation. Albrektsen and her colleagues have developed a process to

release the minerals in fish bones and have come a long way with a process to release the proteins.

The goal of this project is to release at least 85% of the collagen-rich protein in cod bones. If they succeed, the value of fish trimmings will rocket. Extraction of minerals and proteins from cod bones could generate NOK 400–900 million per year, depending on the products developed.

Investigating bioactivity

"Bone components seem to affect muscle quality and health, and this may help to develop a more robust fish," Albrektsen explains.

Fishmeal manufacturer Vedde AS is a partner in this project:

"Our goal is to increase the value of fishmeal for aquaculture in particular and to develop new ingredients for use in feed and food products," says Ola Flesland at Vedde, which is part of the TripleNine Group.



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Agricultural residues – a gold mine?

Each year, Norwegian agriculture produces 415,000 tonnes of residual raw materials. Now plant residues, fat and grain residues are going to be turned into “gold”.

The volumes and types of residual materials in Norwegian agriculture have recently been catalogued.

“The goal was to create a better overview over the volumes, composition, quality, current use, and possible new uses of residual raw materials from industrial processing of agricultural produce in Norway,” says Nofima scientist Diana Lindberg, who was responsible for the report.

High exports

Norilia is one company that already is making profit from what used to be treated as waste. Using 150,000 tonnes of excess products from Nortura (skin, gut, wool and meat), they now have an annual turnover of NOK 500 million, with a high level of exports. Another is Norner, which with Innovation Norway’s support is developing innovative biodegradable plastic based on natural fibres from potato peelings.

Huge untapped resources

Each year, the agricultural industry in Norway produces huge volumes of residual raw materials from different sources: grain processing (69,800 tonnes), breweries (17,000 tonnes), meat (264,000 tonnes), and vegetables and potatoes (64,150 tonnes).



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Scientist Diana Lindberg develops valuable products from residual raw materials from Norwegian agriculture.

A large and often unappreciated resource is animal fat. The current annual volume is 27,300 tonnes, and in addition, meat producers have started reducing the fat content in their products to meet dietary recommendations, resulting in increasing volumes of residual fat.

“Today most of this fat is used in feed. Animal fat consists of a wide variety of oils and fat-soluble compounds. This raw material can be refined to yield a healthier fat that can then be used as, for example, an ingredient in foods,” says Nofima lipid specialist John-Erik Haugen.



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Social sustainability requirements

The Norwegian fisheries industry may soon have to prove that it is socially sustainable.

Social sustainability includes decent pay, health and safety standards, absence of forced labour and child labour, anti-corruption, and fair treatment of suppliers – at all levels in the supply chain. The market is increasingly requiring social sustainability.

Leading the way

“The international backdrop is serious human rights violations on fishing vessels in SE Asia, including slave labour and maltreatment. Retailers in Europe are now also demanding social sustainability, which will be reflected in requirements for the fisheries industry,” says Pirjo Honkanen, Research Director at Nofima.

In Norway, the Fishery and Aquaculture Industry Research Fund (FHF), on behalf of the entire fishing industry, wants to lead the way and commissioned Nofima to gather knowledge about social sustainability certification schemes in catch-based fisheries. What do customers want? What do existing standards say? How do Norwegian regulations com-

pare with international voluntary standards? And not least: how should the Norwegian fisheries industry relate to the requirements for increased social sustainability?

Together with Honkanen, scientists Bjørg Helen Nøstvold from Nofima and Anne Mette Ødegård from FAFO have charted the status in the markets.

Brochure

Their findings have been published in a brochure in Norwegian, along with a concrete recommendation:

“The Industry in Norway must work together to hammer out a document that shows how social sustainability is ensured throughout the entire value chain in Norway. The international standards for social sustainability are still in the design phase, and by addressing this issue early, we can help set the agenda and influence the end result. Representatives from shipowners, fishermen, land-based industry, workers and possibly supervisory authorities should participate”.



PHOTO: FRANK GREGERSEN © NOFIMA

The market is increasingly requiring social sustainability. Soon the industry may have to prove that it is socially sustainable.



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MORE INFO:
Link to the
brochure





PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

"Genetic markers are powerfull tools to breed for fish with higher resistance against diseases such as PD", says Hooman Moghadam.

Genetics improves fish resistance

The combination of three genetic markers on three chromosomes can be the key to high survival after viral infection in salmon farming.

In a trial where fish were challenged against salmon pancreas disease (PD) virus, no mortality was observed in one particular group of fish. These fish were carrying a combination of three different genetic markers on three different chromosomes.

Found good markers for PD resistance

The finding comes from the breeding nucleus of SalmoBreed and is part of the "SalmoResist" research project, led by Nofima. A main aim of this project is to identify association between higher resistance against certain viral diseases, including PD, with the genetic content of the fish.

SalmoBreed and Nofima identified genetic markers that are linked to higher resistance against PD. Hooman Moghadam, project leader from Nofima says:

"When we identify genetic markers that explains traits of interest in the fish, we can more accurately select the individuals that are going to be used in breeding programs. In this

study, we identified genetic markers, located on three different chromosomes, to be significantly associated with higher resistance against the PD virus."

Further the reserachers did not find any mortality among the fish that carry a combination of "good" genetic markers from those three chromosomes.

"This finding will help the scientists to identify the very genes that underlie higher tolerance or resistance against this viral disease", says Moghadam.

Valuable for the industry

Borghild Hillestad is the Genetics Manager of SalmoBreed. She clearly sees the benefits of this research:

"By acquiring a deeper understanding of the genes that control resistance to PD, we have a much stronger capacity to breed effectively for resistance to the disease. Genomic selection and PD seemed to be a good match, and SalmoResist confirmed that", says Hillestad.



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How food bacteria survive

Bacteria work together to form highly resistant biofilms, which cause problems in food production.

Scientists from Nofima have been looking at what can be done.

Micro-organisms can undermine food quality and food safety. Dangerous bacteria such as *Listeria* cause serious illness, while spoilage bacteria reduce the shelf life of food.

These bacteria are found throughout the food chain from producer to consumer and thrive on surfaces such as factory conveyor belts. Different types of bacteria can also stick together, to form slimy communities called biofilms. Bacterial biofilms are especially problematic because they are often more resilient than single bacteria. Biofilms are not as easily removed by rinsing, disinfection and washing because the bacteria collaborate and the products are not able to penetrate the film. Biofilms also often develop in places that are hard to reach.

Nofima scientists have investigated how bacteria like *Listeria* are able to establish themselves and survive on surfaces – and what can be done to make it harder for bacteria

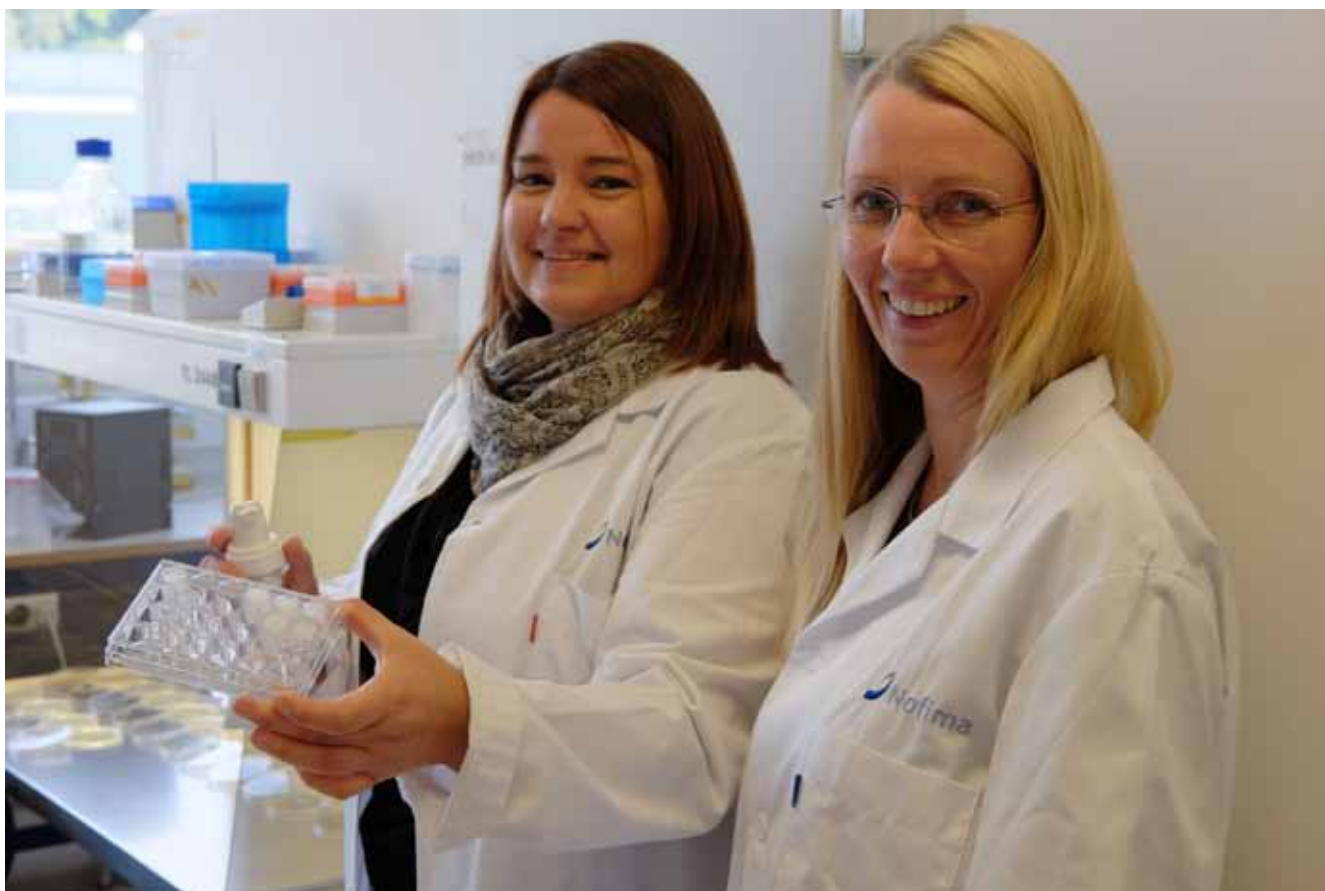
to hide. For example, they have looked at disinfection of production belts in the food industry.

A growing problem

Listeria bacteria are common in nature and can enter the food production chain with raw materials and people.

“*Listeria* is a growing problem and very serious for people with weakened immune systems and the elderly. At the European level, we are seeing a rise in the number of cases of listeriosis, which is thought to be related to higher life expectancy and changes in eating habits,” says scientist Annette Fagerlund.

“In order to simulate the disinfection process in food production, we made a model, allowing us to study this in more detail,” says Solveig Langsrud, senior scientist at Nofima. She explains that the scientists consulted industrial actors in the planning stage, to ensure the studies were realistic.



Annette Fagerlund (on the left) and Solveig Langsrud are working to eliminate food bacteria like *Listeria*.

PHOTO: SIRI ELISE DYBDAL © NOFIMA

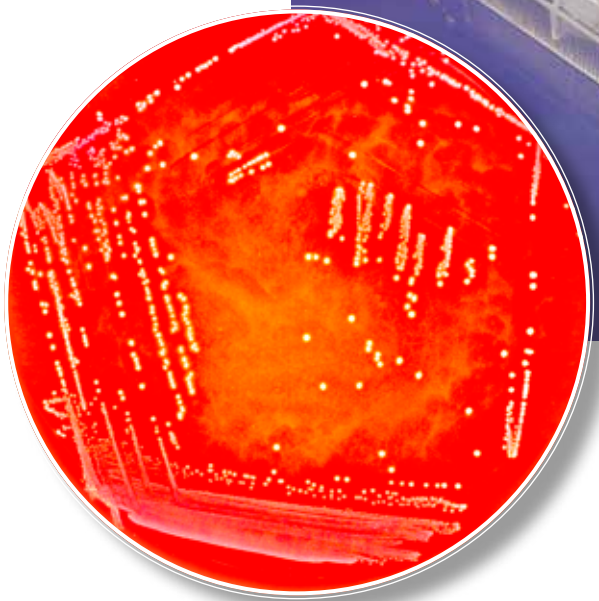


PHOTO: SIRI ELISE DYBDAL © NOFIMA

*Bacteria are cultivated to find out how they live and reproduce. The picture to the left shows colonies of *Listeria monocytogenes*.*

Bacteria hide

The study found that washing and disinfectants kill quite a few bacteria, but unfortunately they often grow back quickly.

“They appear to be gone when you test right away. But all you need is a single bacterium, and they are off again. They grow back over night. The bacteria that survive in the production environment over time seem to be good at attaching themselves to surfaces and better at withstanding the cold,” Langsrud explains, adding that it is especially bacteria that grow in biofilm that survive.

“One problem is that while the top surface of, say, a conveyor belt is made of a smooth material, the underside is often made of another material that is harder to clean. And bacteria hiding on the underside can easily come over to the topside during food production. For example, bacteria can hide in threads on the underside. One solution might be belts that are smooth on both sides,” says Fagerlund.

Other places the bacteria hide are screw holes. Previous studies have found that *Listeria* bacteria can remain in equipment for years. They can get down into a crack and stay there.

Wear and tear

Scratches on equipment caused by wear can also harbour bacteria, meaning it is important to keep equipment in good condition.

“Instead of looking for bacteria, the focus should be on looking for places where bacteria can hide. Whenever possible, equipment should be chosen that does not have suitable hiding places. It is important to continue working to improve designs and cleaning agents,” says Langsrud.

The next step in the project is to study the cleaning agents in more detail.

“We have been contacted by detergent suppliers who want to develop cleaning agents that can remove biofilm, and we have devised a method that allows us to test efficacy here,” says Langsrud.



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PHOTO: FRISENKRONE

"We can't take credit for the products, only for the process behind virgin herring as a raw material," says senior scientist Torstein Skåra at Nofima.

Virgin herring – trendy in Germany

Virgin herring is a winner: full of healthy fats, it is making herring trendy in the German restaurant market.

Behind the scenes, Nofima is proudly watching the product we helped develop become a success.

Virgin herring comes from the same raw material as matjes herring – three-year-old sexually mature herring that have not yet developed roe or milt. The Dutch word "Maatjes" means maiden.

Each year around 140 million matjes herring are produced along Norway's coast.

Prize-winning

Friesenkrone, which markets virgin herring under the brand name "SJØ", has introduced the product in both sushi and tapas versions, and with a number of different flavours developed by creative young chefs, such as chocolate, onions, cream cheese and dill. The German food magazine "Küche" gave "SJØ" first prize in the "Küche Awards" for 2017.

"We can't take credit for the products, only for the process behind virgin herring as a raw material," says Torstein Skåra, senior scientist at Nofima.

The origin is Norway, the North Sea and Nofima. The young herring are caught in a very short season just before spawning.

In 2012 Torstein Skåra and Morten Heide at Nofima were tasked with participating in the development of new herring products. Processes were developed to adapt the flavour and texture of herring to the market's desires and needs. The work was carried out at and in partnership with Egersund Seafood – now Pelagia.

Bright outlook for other markets

"Judging by the popularity of Friesenkrone herring in Germany, the outlook looks bright for other potential markets. A trial introduction of this concept is now being planned in China," Skåra says.

It is incredibly satisfying to see that the manufacturer is winning awards for its work.

"Research is very rewarding when a project you've worked on yields new products that many people enjoy," Skåra says.



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PARTNERS:
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Broccoli makes mashed potato healthier

Eating broccoli with potatoes causes blood sugar to rise less and more slowly than eating potatoes alone, reducing the risk of weight gain and type 2 diabetes, which are both associated with blood sugar spikes.

Starchy foods (potato, pasta, rice, white bread) cause blood sugar levels to rise rapidly. It is thus important to find good meal combinations with ingredients that work with starchy foods to prevent blood sugar spikes.

Nofima scientist Simon Ballance has been doing research on potatoes for several years, and when he discovered the positive effects of broccoli on potatoes, he wanted to find out why.

Measuring blood sugar

The study was conducted on healthy adults, who ate four different meals with equal amounts of mashed potato: with broccoli, without broccoli, with fibre from broccoli and with a different dietary fibre.

"We then measured their blood sugar over a 180 minute period: every 15 minutes in the first hour after the meal, every 30 minutes in the second hour, and then after three hours," Simon Ballance explains.

A number of studies have previously been done in which potatoes are served with various different vegetables. Serving mashed potato with a mixed salad (tomato, cucumber, lettuce) does not have the same positive effect as serving mashed potato with boiled broccoli.

Nor do carrots, peas, Chinese cabbage or Brussels sprouts seem to have any significant effect, whereas spinach has the same promising results as broccoli.

Looking at whole meals

The Nofima scientist is looking at the effect on blood sugar spikes of other typical Norwegian dinner foods such as salmon and carrots when eaten with potato, rice and pasta.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Eating potatoes and broccoli together has a positive effect on blood sugar levels, helping reduce the risk of weight gain and type 2 diabetes.

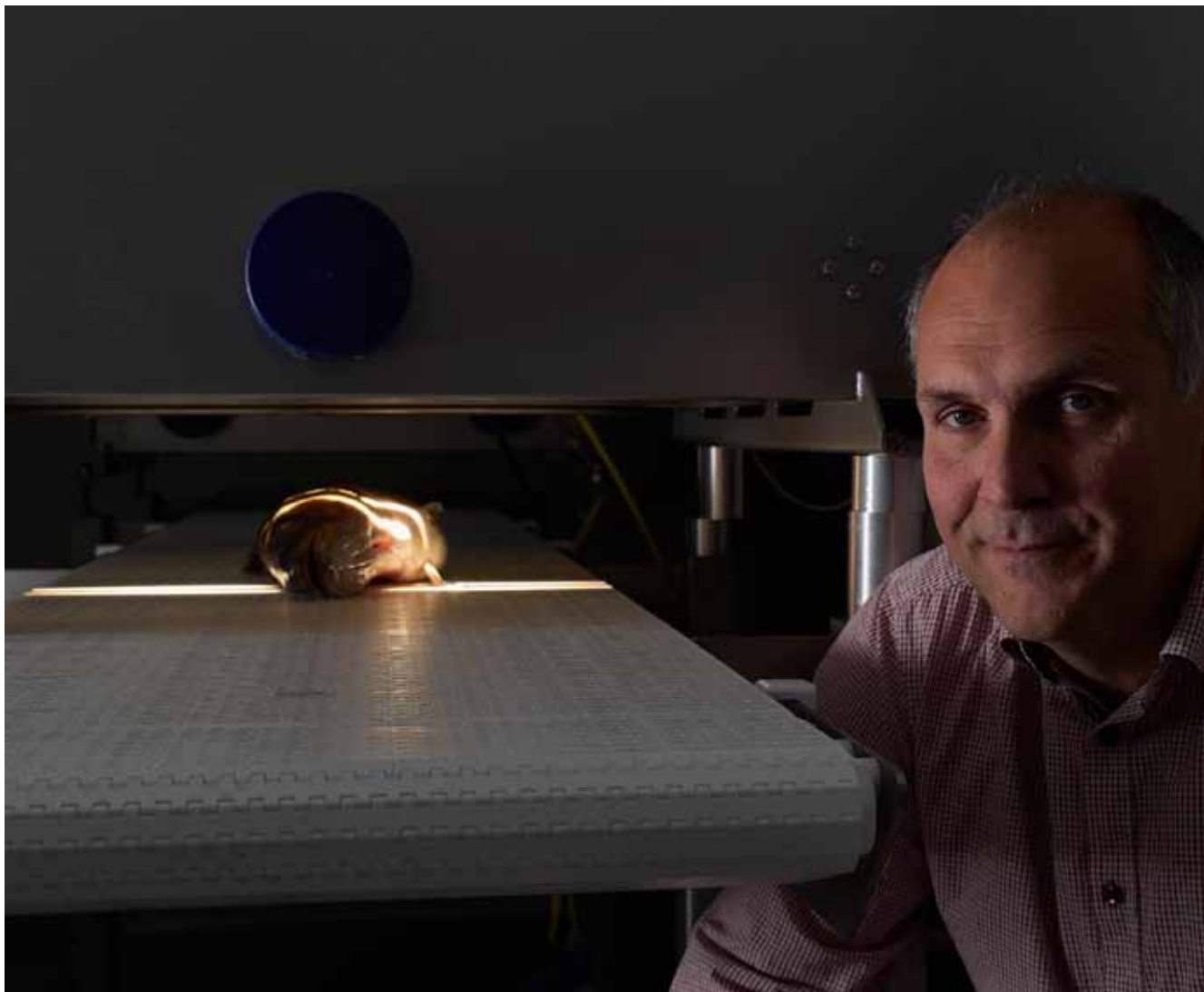
"In reality, no-one eats just potatoes, so research must focus on meals rather than individual foods, especially in terms of effect on blood sugar levels," says Simon Ballance.



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New technology developed by Nofima allows better utilisation of each individual fish and better profitability for the fishing industry.

Bloody serious about quality

An advanced light meter will revolutionise the processing of fish.
Light is being shone on the bloody truth about quality.

The fact of the matter is that white fish can be sorted according to the amount of blood in the fillet – now without having to resort to a knife. New technology developed by Nofima allows better utilisation of each individual fish, and better profitability for the fishing industry.

“We have been working for some years to develop an efficient method of ascertaining quality that can be used on both white fish and red fish, like salmon and trout. Now we have hit the jackpot. We hope to launch a prototype sorting machine that the industry can start using in 2018,” says senior scientist Karsten Heia.

Grading fish flesh with light

The key is spectroscopy.

“In simple terms, spectroscopy is a method of measuring using light. Light is passed through a fish, and we have devised a way to work out how much blood is in the fish muscle, based on how much light is reflected back. Various elements inside the fish absorb light, and we can now identify how much of the light loss is caused by, say, blood,” Heia explains.

For example, it is also useful for producers of red fish to know the fat content of fillets and whether they contain unsightly melanin spots. Spectroscopy can do all this as well.

Whole fish

"We can scan white fish whole, i.e. without cutting them open. We know that 30–40% of the fish landed have a high percentage of residual blood in their flesh. Now we can remove these fish from the production line at an early stage. It is very expensive to send inferior fish for filleting only to discover the real quality there," explains Heia.

Consumers expect high quality white fish to be white. A pink or red fillet means too much blood has entered the muscle. This generally occurs because of stress or injury during capture or slow processing on board.

"Blood in fillets is really only a matter of aesthetics. The fish tastes exactly the same, but consumers are not willing to pay as much for it. If the quality can easily be ascertained before the fish enters the filleting line, it can be processed on the basis of the price it can command in the market. This will also make it easier to reward fishermen who land good-quality catches," the scientist adds.

Profitable grading

Red fish like salmon and trout are a bit more complicated, since both the blood and the flesh are red, so here Nofima's method works best on fillets.

"For example, if you make smoked salmon out of a fillet that contains a lot of blood, there will be black spots in the final product. This is normally not detected until you start slicing up the salmon. In other words, you will have made a product you cannot sell at full price, even though you have

used exactly the same resources to produce it as the ones you can sell at a normal price," says Heia.

In the past, producers have resolved this by buying 25–30% more raw material than they need, because they know that a certain percentage will have to be sold at a lower price.

With spectroscopy, they can determine the blood content of fillets before they start smoking or curing them.

The scientists are currently working with equipment suppliers and the industry to develop a commercial product from this method, in collaboration with domestic and international business partners.

Nofima – Strategic Research Initiatives

With a view to providing businesses with the expertise they need to deliver top-quality products, Nofima is developing world-class research in selected areas. Spectroscopy is one such area, and through the Spectec project, a Strategic Research Initiative, scientists are working to improve and develop new and better rapid measuring methods using light.



PHOTO: SJURDUR JOENSEN © NOFIMA

Blood in fillets is really only a matter of aesthetics. The fish tastes exactly the same, but consumers are not willing to pay as much for it.



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Salmon skin – a living sensor

Nature can often outperform the most sophisticated man-made systems – if we look closely enough. Salmon skin is a case in point.

Do salmon thrive in pens, or are there factors that impair their welfare, health and quality? This growth industry needs systems to continuously monitor the environment in closed facilities. Our research shows that salmon's own skin can do just that – much like a living sensor.

Ideal monitor

"Fish skin protects the fish against the environment, blows and infections, and it reacts quickly and adapts to changes in the environment, making it ideal for biological monitoring of fish welfare and health," says Nofima scientist Elisabeth Ytteborg.

At the CtrlAQUA centre for research-based innovation, Nofima is researching monitoring of fish health and water quality in closed facilities, focusing on the outermost cells of fish skin. Both skin layer thickness and the number of mucous cells are important indicators and change with the surroundings.

Reflects the environment

Fish were tested in various environments. The tests showed that stressed fish from flow-through systems had thinner skin layers, while fish from recycling facilities had a higher number of mucous cells.

"We found that the fish's skin reflects the environment it lives in. This means we can take samples of fish skin that have 'stored' information about the environment and analyse them to monitor fish welfare," says Ytteborg.

It is too early to conclude which type of facility is better. It is the cells and the biology behind these experiments that is the main finding and of value now.

"We are now looking for easy ways to use this living sensor to assess the conditions in pens. This is an important finding that can be used to monitor the fish and the water, and generally improve how we farm salmon in closed systems," the Nofima scientist concludes.

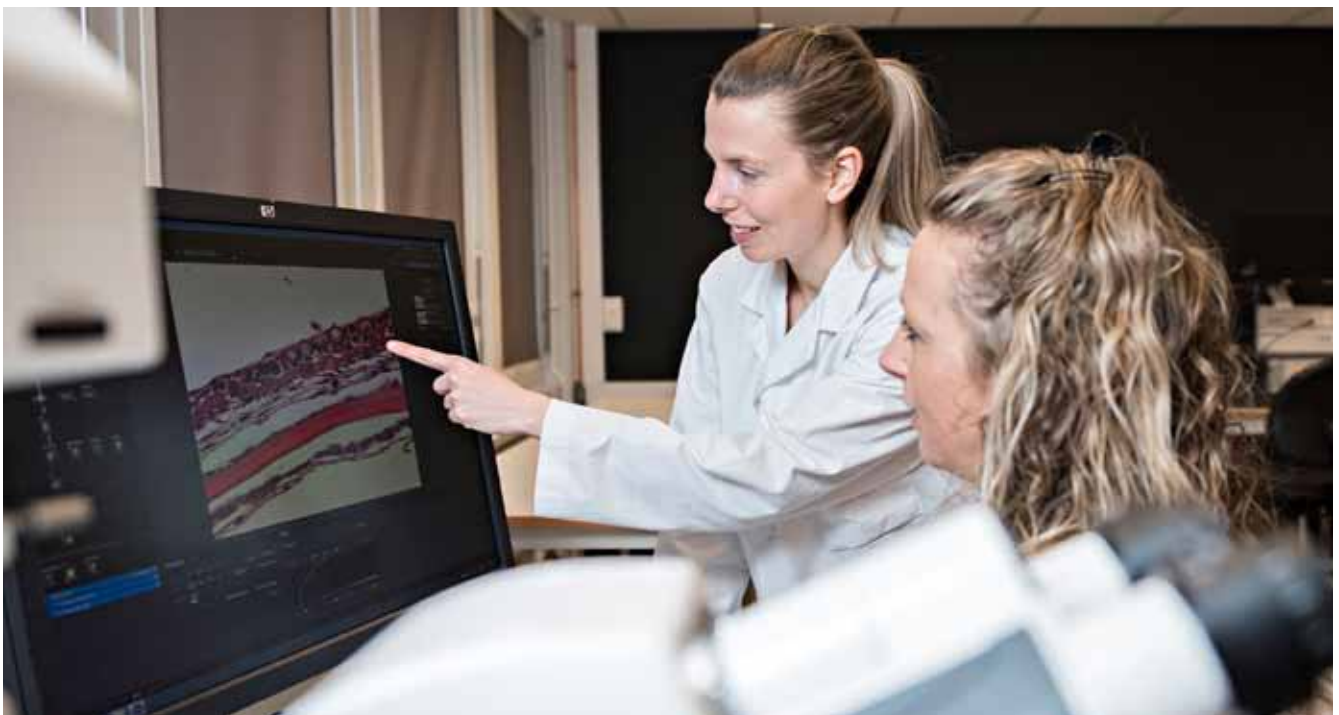


PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Lene Sveen (left) and Elisabeth Ytteborg are working on skin health in farmed salmon. The skin reflects the environment the fish live in.



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overseas



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

The beer in the barrels can be developed according to your taste, because robots pick up your comments on social media for use in innovation work.

Ideas via artificial intelligence

When you comment on posts in Facebook forums, you may also unwittingly be contributing to innovation.

This is artificial intelligence in practice.

Social media are already used to harvest good ideas, but manually this is very time-consuming. Kasper Christensen, who wrote his doctoral thesis at Nofima as part of the strategic research programme InnoFood, wanted to find out whether artificial intelligence can do the job just as well. He developed a method to teach a robot to identify ideas in comments fields on social media, which can potentially become an important tool for innovation.

"The goal is more targeted product development. Hunting down the next major innovation is very expensive. Many new products fail, primarily because companies have not learnt to identify the best ideas from the start," says Christensen.

Beer used for method testing

Beer is a topic that engages many people, also on social media, making it ideal to test whether a robot can be taught to identify good ideas.

Two experts helped Christensen catalogue 200 ideas about beer. The ideas were selected by the robot, and the experts judged how good they were in terms of novelty, commercial potential and feasibility. Both beer experts were impressed by the quality of the data selected by the robot.

Systematic and intelligent

For the huge volumes of data in online forums to be useful, they must be managed systematically and intelligently.

"This is where AI comes in. I have taught a robot to identify ideas in comments by constantly feeding it new facts, so that it learns and becomes smarter. This is possible because people use specific words and phrases when talking about ideas. And it is these that the robot learns to recognise," says Christensen.

However, what constitutes a good idea is quite subjective and can vary from company to company and person to person and needs validation with the consumer.



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PHOTO: TERJE AAMODT © NOFIMA

"We have looked at which indicators work best in seven different production systems," says scientist Jelena Kolarevic.

Book on fish welfare

Scientists have compiled a handbook containing research-based advice on the best indicators to use to assess farmed salmon welfare.

In the 305 page guide, the researchers outline a number of "welfare indicators" – individual factors that each say something about the fish's level of welfare. Examples include appetite, emaciation, surface activity, reflexes, behaviour, epidermal injuries, fin damage, gill status, sea lice levels and temperature.

40 different indicators

Operational Welfare Indicators (OWIs) are indicators that fish farmers can easily use in their day-to-day operations. Laboratory-based Welfare Indicators (LABWIs) are sampled on the farm but then sent to a laboratory for evaluation. The book covers some 40 different indicators and outlines the different rearing systems and routines they are best suited to.

"The goals of the project are to provide the user with correct fit-for-purpose tools for measuring fish welfare, based upon sound science. With this in mind, the FISHWELL team have reviewed the fish's welfare needs and what scientifically documented welfare indicators are suitable for salmon," says senior scientist Chris Noble, who has led the FISHWELL project.

A milestone

The manual is divided into three parts. The first gives an updated scientific overview of the welfare needs of salmon at different stages of life and the different welfare indicators. The second part tells us which indicators are most appropriate to use in different aquaculture facilities. The last part provides good advice on how to monitor the fishes' welfare under different husbandry routines or practices, for example during transport or for harvesting.

"The work that has been done is a milestone, and has resulted in a tool box with welfare indicators that are easy to use and will help fish farmers be better able to document fish welfare. At the same time, it is important to note that the reports do not directly indicate what is considered acceptable or not; this is up to others to evaluate," says Kjell Maroni, FHF's R&D Director for aquaculture.

In 2018 a corresponding guide will be published for rainbow trout



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The Institute of Marine Research, the Norwegian Veterinary Institute, North University in Bodø and the University of Stirling, UK

MORE INFO:
Read the book



Best practice against lice

The best way to keep sea lice at bay is to use proven methods, avoid handling and allocate enough people and time.

Through the MEDFRI project, tips and advice have been collected in a compendium that is primarily aimed at fish farmers and suppliers of methods.

"The compendium facilitates choices that are good for the fish and the farmer alike and bad for the lice," says project manager Åsa Espmark at Nofima.

Without medications

In the period January to April 2017, scientists reviewed the most widely used, non-medicinal methods of fighting sea lice. They gathered scientific evidence, and fish farmers and method suppliers shared their valuable experience. This knowledge has been now compiled into a "best practice compendium". Best practice means effective methods that do not negatively impact salmon welfare. Cost has also been taken into account, where possible.

The scientists have assessed non-medicinal methods, both with and without handling, preventive technological and biological measures, and combinations of methods.

The main conclusion is that methods involving handling of fish are more likely to result in injury and poor welfare. Degree of documentation of the methods varies greatly. The compendium also provides relatively detailed advice about the use of the individual methods.

Enough people and time

Espmark wants the compendium to raise the users' awareness about non-medicinal lice control:

"Breeders must use proven methods and be dedicated to the task. They have to learn how to use the methods properly and set aside enough people and time," says Espmark.

Not least, the suppliers of mechanical lice control methods must provide neutral documentation of the methods.

"Non-medicinal sea lice control methods are in continuous development, and hopefully we will see further improvements now we have identified a number of shortcomings," Espmark concludes.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

The researchers behind the sea lice compendium have travelled all around Norway and gathered knowledge on best practices from farmers and suppliers.



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MORE INFO:
Read the
report



Healthy “waste”

When cabbages and tomatoes are harvested, much good raw material remains. This “waste” can be made into new, healthy products.



PHOTO: © NOFIMA

The “waste” left behind in the field when the cabbage heads have been harvested can now be turned into new, healthy products.

The EU project “Sunniva” is about different methods of processing raw materials, by-products and waste from tomato, white cabbage, cauliflower and broccoli: innovation to reduce food waste.

The goal is better utilisation of raw materials, reduced energy and water consumption, higher profitability, and healthier food.

“Scientists and industrial players from seven countries have studied raw materials from harvest to finished product, and have come up with many ways to reduce waste and make good, healthy products. Researchers all over Europe have worked on the project, and many different methods have been used to improve exploitation, benefiting the environment, the economy and nutrition,” says Nofima scientist Trond Løvdal.

Findings and results

After three years, the findings and results can be summed up thus:

- Optical sensors have been developed to measure the amount of health-promoting substances in tomatoes and cabbages, both before and after harvest.
- Waste from cabbage and tomato plants can be exploited, improving consumer health.
- Use of microwave technology reduces both power and water consumption.
- New technology can produce juices, smoothies and purees without oxidation.
- New organic fertilisers have been developed using vegetable waste.

Value loop

“We often talk about the value chain from harvest to finished product, but in terms of sustainability, we should look at the value loop. This is a life-cycle approach, where the various residual raw materials are exploited to the full: either directly (for food production as a refined product or an ingredient) or indirectly (e.g. fertilisers, compost or animal feed), depending on what adds the greatest value,” Trond Løvdal explains.



PHOTO: ANNE-MAY JOHANSEN © NOFIMA

Researchers and commercial players from seven countries have worked together in this EU project, the goal of which is innovation to reduce food waste.



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PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

"Today Norway's exports of crispbread are worth more than our imports from Sweden 10 years ago," says senior adviser Sveinung Grimsby.

Crispbread – a Norwegian success

In recent years, exports of fancier, "home-made" Norwegian crispbread have skyrocketed.

From just under NOK 20 million in 2014, exports have risen to almost NOK 100 million in 2017.

It is the fancier, more exclusive varieties that have experienced the greatest increase in demand. Sales volumes of Norwegian crispbread have only increased by a quarter, while sales value has doubled.

Open innovation

Senior adviser Sveinung Grimsby at Nofima has studied innovation in the Norwegian grain industry. In a nutshell, the success is due to greater willingness to pay and open innovation.

"Prior to 2012, there was no industrial production of crispbread in Norway. In 2011 the project Open Innovation Cereal was concluded, the purpose of which was to foster new ideas and explore the industry's opportunities. 17 ideas were presented to the industry," says Grimsby.

Six years later, several of the ideas have become products. Crispbread is by far the most successful.

"I have investigated whether there is any link between success and openness and interaction in innovation processes," Sveinung Grimsby says.

Healthy crispbread that doesn't crumble

His research shows that the businesses interact and are more open in practice than they often are aware of, and this is good for innovation. However, a number of factors must be present for businesses to open up.

"The companies must trust each other, they should be roughly the same size, and ideally they should not be competing for the same customers," the scientist says.

One insight shared in 2012 was that people do not eat crispbread in their cars because they leave crumbs in the seats. Another was the potential of marketing crispbread as a healthy snack. Based on this, several manufacturers have succeeded in producing tasty "home-made" crispbread that doesn't crumble, which they market as a healthy snack.



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PHOTOS: WENCHE AALE HÆGERMARK © NOFIMA



▲ In the Nofima bakery, the correct recipe for the lefse called kling has become available after multiple trials. Gro Hommo (to the left), Inger Marie Bakås, Ane Underberg and Nofima-baker André Løvaas.

◀ The lefses called klings are popular in Telemark. Now three of the county's bakers have developed artisanal klings for sale in large parts of Norway.

Make way for the Telemark *kling*

Three entrepreneurs, who currently each run their own bakery business, have established a joint side line, with the goal of selling Telemark *klings* all over Norway.

Independent bakers Gro Hommo (Lega), Ane Underberg (Heimebakeriet) and Inger Marie Bakås (Skreppa) have worked together to come up with a variant of the traditional Norwegian soft flatbread “kling” that they all agree on. There are many traditions and experiences to take into account in this development process. At the same time, they are all going to continue baking their own klings separately.

“Making artisanal *klings* is hard work and time-consuming, because the production process involves many steps. One of the most cumbersome steps is soaking the kling after it has been cooked,” explains Gro Hommo of Lega, who initiated the product development collaboration.

Experimenting in Nofima’s bakery

Together with Nofima baker André Løvaas, the three entrepreneurs have tried to find ways to simplify the production process, without compromising on taste, texture or appearance.

Another challenge is preserving the fresh flavour: making *klings* with a long shelf life that nevertheless taste freshly baked, even though they have been stored for a while.

“Traditionally, *klings* were dried for storage. Now it is more common to freeze them, but it would be better if they could be refrigerated rather than frozen,” says Inger Marie Bakås of Skreppa.

In the Nofima bakery, the artisanal bakers and André try out many different dough recipes. They roll out dough, cook, stretch, study and taste, but it is never quite right. The *kling* is too dry, or tasteless, or too sticky. Adjustments are made, and even more dough combinations are tested.

They add different ingredients to find out how they affect the dough. What happens if we add, say, more sugar, or eggs, or cooked semolina?

“Priceless”

“These experiments show us how the different ingredients affect both cooking times and properties such as taste, texture and appearance. Seeing and understanding what the different ingredients do is a great learning experience. This

visit to Nofima has been incredibly instructive and interesting, it’s simply priceless,” says Gro Hommo.

Trial and error pay off, because towards the end of the day at the Nofima bakery, the bakers break into big grins. They can hardly believe it; it is a real Eureka moment. For at last, the bakers know that they are on the right track for a really good dough – it is easy to work with, and the flavour, texture and appearance are all up to scratch.

“People have great expectations of us and this project in Telemark, and the Western Telemark business nursery is helping us with our development work. Since the visit to Nofima we have continued developing the recipe, and we really feel that we are on the right track now,” says Gro Hommo.

Visit scheme for local food producers

The days at Ås are part of the visit scheme for local food producers. The visit scheme is a unique offer where local food producers can work one-on-one with an expert on a specific issue.

“Through the visit scheme, small businesses can also experience team work on resolving a problem or product development. The visit scheme gets very good feedback, especially because it can be tailored, which in turn motivates producers to seek help and support from experts,” explains Stine Alm Hersleth at Nofima, project manager for the competence network for local region East.

The competence network for local food

Local food producers can receive help with development and wealth creation. Five competence hubs cover the whole of Norway and arrange courses, seminars, networks, study tours, internships and visits, adapted to the companies’ needs.



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Kompetansenettverk
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network’s
website



Farmed salmon need marine omega-3

A doctoral project shows that more than 1% marine omega-3 fatty acids in feed are essential to preserve the good health of farmed salmon.

Norwegian salmon farming has more than doubled over the past ten years, resulting in increased demand for feed ingredients.

Since the supply of fish meal and fish oil is limited, current salmon feed consists of roughly 70% plant proteins and plant oils. This has led to reduced levels of healthy, marine omega-3 fatty acids in the salmon's tissue and organs.

EPA and DHA fatty acids

The demand for fish oil resources will increase further in the future, requiring new knowledge about salmon's minimum requirements for essential omega-3 fatty acids.

In her doctoral project, Marta Bou Mira at Nofima studied the minimum levels of marine omega-3 fatty acids in feed required to ensure good health and growth in farmed salmon. She studied two fatty acids (EPA and DHA), whose main source today is fish oil. There is limited access to fish oil in the market, meaning it is preferable not to use more than necessary in aquaculture feed.

Too low

In the doctoral work, salmon were fed from 0 to 2% EPA and DHA in feed from the juvenile stage and up to a slaughter weight of 4 kg. Bou Mira's work shows that in purely resource-economic terms, it is profitable with up to 1% marine omega-3 fatty acids in the feed, as this provides the highest own production of omega-3 in salmon. However, trials showed that 1% EPA and DHA in the feed (the level that was previously considered adequate) is too low for the salmon to maintain good health in the demanding environment in pens at sea.

The lowest levels of omega-3 fatty acids in the feed led to structural changes in the intestine and spine and a higher mortality rate after sea lice treatment.

The content of marine omega-3 in commercial feed is well above the levels that resulted in negative effects in these trials.



PHOTO: KJELLRUN HOÅS GANNESTAD © NOFIMA

Marta Bou Mira has studied the minimum level of marine omega-3 fatty acids in the feed that will ensure good health and growth of farmed salmon.



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The Norwegian fish processing industry is struggling to be competitive for Norwegian workers, but is very competitive in the EEA.



PHOTO: OLE ASHEIM © NOFIMA

Fewer Norwegians working with fish

The fisheries industry is not very attractive to Norwegian workers, while workers from EEA countries welcome jobs here.

More than 50% of the employees in the Norwegian fish processing industry in 2017 are foreign workers, compared with 12% in 2003.

“The increase in overseas workers suggests that the fish processing industry is struggling to be competitive for Norwegian workers, but that this industry is very competitive in the EEA,” says senior scientist Edgar Henriksen at Nofima.

Less than half are Norwegian

Commissioned by the Ministry of Labour and Social Affairs, he has led the work on a report on the use of layoffs and foreign workers in fish processing.

The results can be broadly summarised as follows:

- The share of Norwegians in permanent posts fell from 88% in 2003 to 58% in 2013.
- By extension, probably fewer than half of the workers in fish processing are now Norwegian.
- Seasonal variation and inability to offer year-round work are the reasons Norwegian workers do not want to work in the fisheries industry.

- Most of the increased share of foreign workers are from Eastern Europe.
- The use of layoffs has declined.

Well educated

Norwegian workers do not accept only a few months of work a year, while the wage level in Norway is often five times what workers can earn in Eastern Europe.

“The processing industry in Norway is far from causing wage inflation, but wages here are still much higher than workers in many EEA countries can earn at home. Therefore, people often are happy to take seasonal work in Norway,” says Henriksen.

He is not concerned about the quality of the overseas workers:

“Many foreign workers are well educated. They are also often motivated to prove their merit. Overall, foreign workers are no different to Norwegian workers in terms of quality,” he says.



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Copia

MORE INFO:
Link to report
in Norwegian



Breeding for more omega-3 in salmon

New findings have revealed differences in the heritability of EPA and DHA in Atlantic salmon.

This is important knowledge for breeders.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Feed has the greatest impact on the fatty acid composition in salmon. However, genetics also plays a role.

In the last decade, production of Norwegian farmed salmon has more than doubled. Since the supply of fish meal and fish oil is limited, salmon's diet has also changed.

Today salmon feed consists of roughly 70% plant proteins and oils. This has led to a decline in the level of the healthy omega-3 fatty acids in the fish.

Can produce the healthy fatty acids

Salmon can actually increase the amount of healthy omega-3 fatty acids in their bodies, by converting shorter chained fatty acids from plants into longer chained marine omega-3 fatty acids. This trait is probably linked to the fact that they spend the first part of their lives in fresh water. In fresh water, wild salmon need to produce marine omega-3 fatty acids themselves, because they do not have access to them in the food they eat. In salmon farming, EPA and DHA is provided in the feed throughout the whole lifecycle.

Previous research has shown that some salmon families have higher levels of the healthy fatty acids in their muscle tissue than others. These kinds of differences can be used in breeding programmes to breed salmon that are better able to produce marine omega-3 fatty acids themselves.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Doctoral student Siri S. Horn has studied the heritability of each omega-3-fatty acid. She has found major differences in heritability between the major marine fatty acids EPA and DHA.

Different omega-3 fatty acids

Salmon contain many different omega-3 fatty acids. Doctoral student Siri Storteig Horn at Nofima has studied the heritability of each individual fatty acid in the SalmoBreed breeding population. She has found major differences.

"The main marine omega-3 fatty acids in salmon are EPA and DHA. Our findings show that the muscle content of EPA has low heritability, while DHA has quite high heritability, estimated at 26%. In other words, genes determine 26% of the variation in fatty acid content in muscle tissue, meaning there is great potential in increasing this fatty acid through selective breeding. The results also indicated that a fish that has a high level of EPA does not necessarily have a high level of DHA," says Horn.

Her doctoral research is part of the project "Genomics of omega-3 in Atlantic salmon". This four-year project is funded by the Research Council of Norway and has a budget of NOK 10 million.

It is currently very time consuming and expensive to measure the fatty acid composition of the high number of individuals needed for breeding. Scientists at Nofima are working to develop a new and faster measurement technique.

"A new rapid measurement method will benefit salmon breeding companies if they want to select fish with increased levels of marine omega-3," says Horn.

The next step

The next step in the doctoral work is to determine which genes and gene variants influence the fatty acid composition of salmon muscle. This will tell us more about the physiological processes that affect the fatty acid composition in muscle, and contribute to more efficient implementation in breeding programmes.

"We know that this is a heritable trait, meaning it is possible to increase omega-3 content through selective breeding. To learn how omega-3 content is regulated, we need to study which genes are involved. Our data show that the production of marine omega-3 fatty acids and their deposition are two different traits", says Horn.

Facts about omega-3 in salmon

- There is about 1 gram of the healthy marine omega-3 fatty acids EPA and DHA in 100 g salmon fillet.
- Eating salmon once or twice a week is enough to meet the recommended intake of marine omega-3, according to the European Food Safety Authority.



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"Correct packaging can reduce food waste and thus have a positive effect on the environment," says Marit Kvalvåg Pettersen and Valérie L. Almli.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Packaging reduces food waste

The environmental impact of throwing food away far exceeds that of packaging it in plastic.

Many people think a lot of packaging is unnecessary and merely serves to make items more expensive or force us to buy larger quantities. However, the main function of packaging is to protect the food. The environmental impact of throwing food away is far greater than that of the packaging. In developing countries, up to 50% of food is wasted, in part due to poor packaging.

"The problem is not the packaging itself, but what people do with it after it has served its purpose," says Marit Kvalvåg Pettersen, a scientist at Nofima.

Limp without packaging

Packaging solutions that make food last a few days longer can greatly reduce food waste.

Given the choice, would you pick limp broccoli or firm? Most people prefer firm vegetables, and limp ones often end up in the bin. In this context, it is useful to know that unpackaged broccoli goes limp in less than a week, while packaged

broccoli will stay firm for over two weeks. The same goes for cauliflower.

"We have also seen that if we add a label that says 'packaged for longer shelf life', more people choose the packaged variety," says Nofima scientist Valérie L. Almli.

Huge impact on food waste

Studies show that, given the choice between two sushi packages both produced on the same day, consumers choose the one with the longest use-by date. If in addition the label says 'new packing technology for longer shelf life', more people are willing to choose sushi produced two days ago.

"Correct packaging can reduce food waste and thus have a positive effect on the environment," says Marit Kvalvåg Pettersen.

Then it is simply a matter of making sure that, once it has served its purpose as a food protector, the packaging is disposed of properly and does not end up in nature. That is a responsibility we all share.



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New oil source for salmon?

Preliminary trials and analyses of omega-3-rich oil from genetically modified rape seed indicate that it is safe to use in salmon feed.

Aquaculture needs new sources of marine omega-3 to meet the potential for growth in the industry. Nofima is currently testing omega-3 Canola, a rapeseed oil rich in the marine fatty acid DHA.

Broad set of trials

Nofima has performed feed trials on salmon in fresh water and in sea water facilities on land, where increasing amounts of omega-3 Canola were added to the feed. A parallel trial has been carried out on fry in warmer water in Australia, to test the omega-3 sources at different growth rates. This is important to detect any effects that occur with rapid growth in early life.

The salmon given feed containing omega-3 Canola were analysed for growth, composition and health.

No differences

The salmon fed with omega-3 Canola had the same fillet omega-3 levels as salmon fed with fish oil. Gene expression analyses showed that effects depended on the amount of oil, not the type of oil. "Thorough analyses of these results have

not shown any differences in health and growth between fish fed the two oils," says Bente Ruyter, project manager at Nofima.

NIFES has analysed the omega-3 Canola oil, from the Australian company Nuseed, and did not find any DNA traces of genetically modified rape seed. The oil is extracted from rape plants that have been genetically modified to produce DHA.

Trials have also been performed with salmon growing from 0.5 to 1.2 kg in tanks on land in Sunndalsøra. The fish were given feed with increasing levels of omega-3 Canola, the results of which are currently being analysed.

New knowledge

"The results will be published in open journals," says Ruyter.

Whether this oil is cleared for use in feed depends on government regulations. Then it is up to the industry to decide whether to use the new feed sources. Knowledge from this project will provide a basis for these decisions.



Bente Ruyter has researched whether Canola, oil made from genetically modified rape seed, is a safe source of marine omega-3 for salmon feed. So far it looks very promising.

PHOTO: JON-ARE BERG-JACOBSEN, MONTAGE: ODAHL © NOFIMA



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PARTNERS:
CSIRO (Australia) og
NIFES (Norway)

MORE INFO:
Visit the
project's web-
site





PHOTO: BJØRN-STEINAR SÆTHER © NOFIMA

The fish hotel of Nergård Sørøya in Finnmark. Here the catch can be kept alive and in good shape until the market is ready for buying it.

Good investment!

Our research on fish hotels was granted status as National capture based aquaculture competence centre. We are now in a much better position to store wild fish and shellfish – alive.

Transport tanks on board fishing vessels. Knowledge about feed and feeding. Special sorting criteria to remove fish that will not withstand live storage. A guide to capture-based aquaculture, giving “everyone” the chance to try and keep their catch alive in sea pens or tanks, until the market is ready for them.

These are just a few examples of new tools and knowledge to help fishermen succeed with live storage.

“I would claim that the Centre has been a good investment, in terms of improvements in product quality, fish welfare and wealth creation,” says senior scientist and head of the Centre, Bjørn-Steinar Sæther.

Predictability for the market and the ability to deliver top-quality seafood all year round are the main motivations behind live storage of catches.

Next species – haddock?

In Norway it is mainly cod, crab, cleaner fish and sea urchins that are stored alive. The amount of live-stored fish is on the rise, although it currently represents only a fraction of the fishing quotas.

Now a new species can check in to the hotel, at least for a short stay. Trials at keeping haddock alive on the journey from fishing grounds to factory have surpassed expectations.

“Up to 80% of the haddock were still alive 12–18 hours after capture. The fillets were perfect and suitable for all uses,” says scientist Torbjørn Tobiassen.

Haddock is an excellent food fish, but is usually difficult to handle. The Båtsfjord facility, which processed the test haddock, reported significantly better quality. The fish were easy to work with, and the proportion of top-quality products increased by 25%.

Now the researchers want to repeat the experiments, in part to find out why some fish don't survive.

More work to be done

How many wild fish survive capture varies widely: at best, 95%, but at times only half.

"So there is still more work to be done. For example, we need to document which fishing methods work best, how they should be used, and the size of the catch and transport time affect survival, quality, and fitness for live storage," says Sæther.

The Centre has also run courses for fishermen. In addition, the scientists have worked with teachers at upper secondary schools in Lofoten and Vesterålen, and live storage is now on the syllabus of the fisheries programmes there. The centre also give lessons at the University of Tromsø.

Shellfish also benefit from live storage. Nofima has focused on king crab and snow crab. We now know more about what they need to stay alive, and also about the opportunities for Norwegian players in the markets for live crab in Asia and the USA.

Live crab commands a good export price, but producers of claws and legs also get better results if crabs are stored alive. It gives the crabs the opportunity to recover from the rough treatment in the nets and during capture.

International attention

The extensive trials and the results in terms of quality have made the scientists involved sought-after speakers around the world. Nofima has also received assignments from players from Canada, Denmark and Iceland, to name but a few.

The scientists themselves have also been inspired by techniques overseas, such as live storage of tuna in Croatia. There they also keep the tuna alive in the nets after capture, so that they can be slaughtered one at a time to preserve optimal quality.

"This is an extreme version of what we are doing. However, the principle is the same, whether it is tuna, cod or crab. We want to preserve the quality of the catch and handle the fish individually," says Sæther.

The National Centre for Capture-based Aquaculture was established in 2010. It is funded via the national budget and is headed by Nofima.



Haddock fillet – from live-stored (top) and conventionally caught haddock.

PHOTO: TORBJØRN TOBIASSEN © NOFIMA



"Live storage of wild fish and shellfish improves the food quality, fish welfare and wealth creation," says the head of the Centre, Bjørn-Steinar Sæther.

PHOTO: AUDUN IVERSEN © NOFIMA



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PHOTO: AUDUN IVERSEN © NOFIMA

If research is to help resolve challenges facing society, we need to collaborate across national borders, says scientist Petter Olsen.

Setting new international goals

Nofima is aiming to expand its international collaboration.

This will also benefit Norwegian trade and industry.

Most research problems are transnational in nature, and people in many countries can benefit from the research findings. Similarly, few issues are unique to an individual company.

"For example, when researching how to combat food fraud, it is pointless to only look at the situation in Norway. The problem often starts long before the food item reaches the Norwegian border. We need to collaborate across national borders to ensure overview and find solutions to the problems," says scientist Petter Olsen.

The impact of climate change on fisheries and aquaculture is another example of an area where international collaboration and global perspectives are essential.

Want more EU-funded research

The EU has invested almost EUR 80 billion in its Horizon 2020 research programme, which runs from 2014 to 2020. So far,

EUR 430 million has been awarded to Norwegian organisations, including Nofima.

But the Norwegian authorities want a larger piece of the pie, since Norway pays large sums of money to be allowed to apply for these research funds. Applying for research support from the EU is hard work, so the Norwegian government gives grants to Norwegian research institutes that want to apply for EU funding.

In line with the national strategy, Nofima's goal is to increase revenues from EU projects from 5% to 10%. To this end, Nofima is focusing on building up areas and networks for researchers who want to work internationally.

Unparalleled success rate

"Good networking is crucial for success," says Olsen, who plays a key role in Nofima's EU focus.

"I am part of two international networks: one on fisheries

► Solveig Langsrud is heading the EU project SafeConsume, where scientists from 14 countries are collaborating for better kitchen hygiene. Here with her colleague Trond Møretrø.

►▼ EU Commissioner for Environment, Maritime Affairs and Fisheries Karmenu Vella and Norway's Minister of Fisheries Per Sandberg visited Nofima to hear to hear our CEO Øyvind Fylling-Jensen talk about Biotech and the EU project ClimeFish.



PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

Horizon 2020 projects in which Nofima is participating:

- Edulia
- SafeConsume
- AQUAEXCEL2020
- ClimeFish
- PrimeFish
- EU-China-Safe
- FarFish
- AgriMax
- MedAID
- VIVALDI
- AUTHENT-NET



PHOTO: ANNE-MAY JOHANSEN © NOFIMA

and seafood and another on food fraud and traceability. In addition, I am part of a tight-knit group of scientists from five institutes who have worked together on many EU projects. We know each other well and discuss the various calls for applications," he says.

Over the last seven years, the EU has granted nine out of ten applications he has been involved in. By comparison, the average success rate in Horizon 2020 is 12%.

Alongside his work on EU projects, Olsen is also Nofima's internal EU coordinator. He keeps track of the many initiatives, applications and projects in which Nofima is involved. In 2017 some 100 scientists were involved in EU research in some way.

An important criterion for most of the EU projects that Nofima participates in is that the research must help resolve concrete problems facing society. This is a good match for Nofima.

"Nofima conducts applied research. This means that the knowledge we generate through our research must be useful for commercial players and the authorities in specific areas.

We are used to seeing problems from the industry point of view, providing us with an advantage compared with some of our competitors," says Olsen.

The industry must do more

The Norwegian private sector spends substantially less money on research than our neighbouring countries, but research activity has been stepped up in recent years. The authorities have indicated that the business community must do more to ensure that we reach the target of research and development expenditure of 3% of GDP.

"It is thus important that businesses and organisations get more involved in research, financially as well. Right now, companies have a golden opportunity with the EU," says Olsen.

"In the coming years, the EU is going to allocate more money for innovation projects, where the research must result in concrete innovations for companies and society. The business community needs to strike while the iron is hot," he adds.



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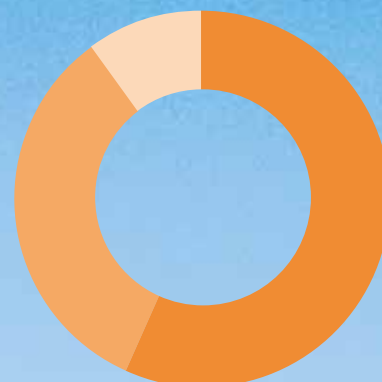
MORE INFO:
Horizon 2020



Facts and figures

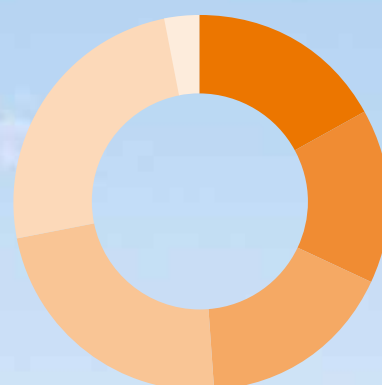
Structure

The Ministry of Trade, Industry and Fisheries	56,8 %	
Agriculture Nutrient Research Foundation	33,2 %	
Akvainvest Møre og Romsdal	10,0 %	



Funders

NFD	17 %	
Basic funding from NFR	15 %	
Project funding from NFR/EU	17 %	
The research funds FHF/FFL	23 %	
Companies	25 %	
Laboratories	3 %	



The following are our largest funding providers

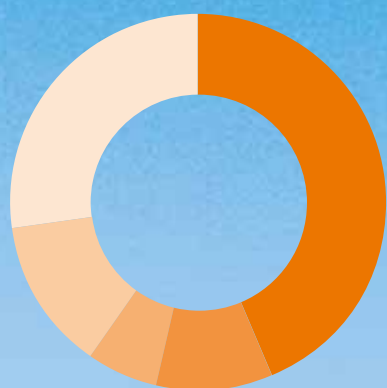
RESEARCH COUNCIL OF NORWAY (NFR) is a strategic organ that identifies priority areas and project/programme managers, allocates research funding and evaluates the research that is carried out.

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.

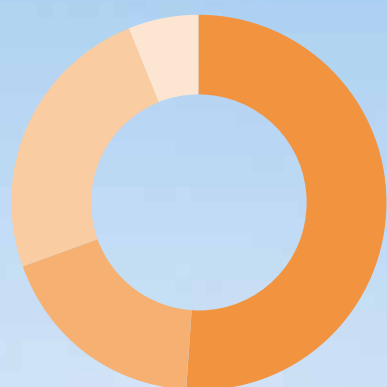
THE RESEARCH FUNDING FOR AGRICULTURE AND FOOD INDUSTRY (FJM)/AGRICULTURE NUTRIENT RESEARCH FOUNDATION (FFL) shall secure an economic basis for research connected to agricultural products that are utilized to produce food and stimulants, as well as feed grain for animals. Financed through a research levy on agricultural products.

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



Geographic distribution of employees

Ås	164
Bergen	38
Stavanger	22
Sunndalsøra	49
Tromsø	102



Employees by function

Scientists and advisers	192
Laboratory engineers/research technicians	69
Technical and administrative staff	92
Managers	22

This is Nofima

Nofima has some 375 employees, and a turnover of NOK 585 million in 2016.

The research in Nofima is organized into three divisions, each organized in research departments:

Division Aquaculture

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

Director Bente E. Torstensen

Division Seafood

- Marine biotechnology
- Marketing research
- Industrial economics
- Processing technology
- Seafood industry

Director Magnar Pedersen

Division Food Science

- Food and health
- Raw materials and process optimization
- Consumer and sensory sciences
- Food safety and quality

Director Camilla Røsjø



PHOTOS: JON-ÅRE BERG-JACOBSEN | LARS-ÅKE ANDERSEN © NOFIMA

New solutions for food producers

The food we eat shall be healthy, tasty and safe. In addition, nothing shall go to waste. To this end, Nofima delivers research-based knowledge and new solutions to commercial players involved in the production of food. Our research shall be a driving force for innovative, sustainable, smart food production.

We are an internationally recognised institute for applied food research, and our some 300 scientific employees conduct research to ensure better food from agriculture, fisheries and aquaculture.

Innovation is key to food research. We are constantly looking for new solutions, and through our worldwide networks we gather knowledge that benefits our clients.

In 2017 Nofima was ranked one of the most innovative businesses in Norway by the magazine Innomag.no. We intend to continue in the same vein.



Engaged • Inclusive • Innovative • Responsible



What is the right food for you?

Some people need food that has been specially adapted to the phase of life they are in, others need food adapted to health challenges they face. The demand for adapted food is growing, and we need more food products tailored to individual preferences and requirements. To this end, Nofima has assembled a solid team of scientists with long experience and broad expertise in food production in a major research initiative focusing on adapted food.

We want everyone to be able to eat good, healthy food – no matter what their situation.

Bon appétit!

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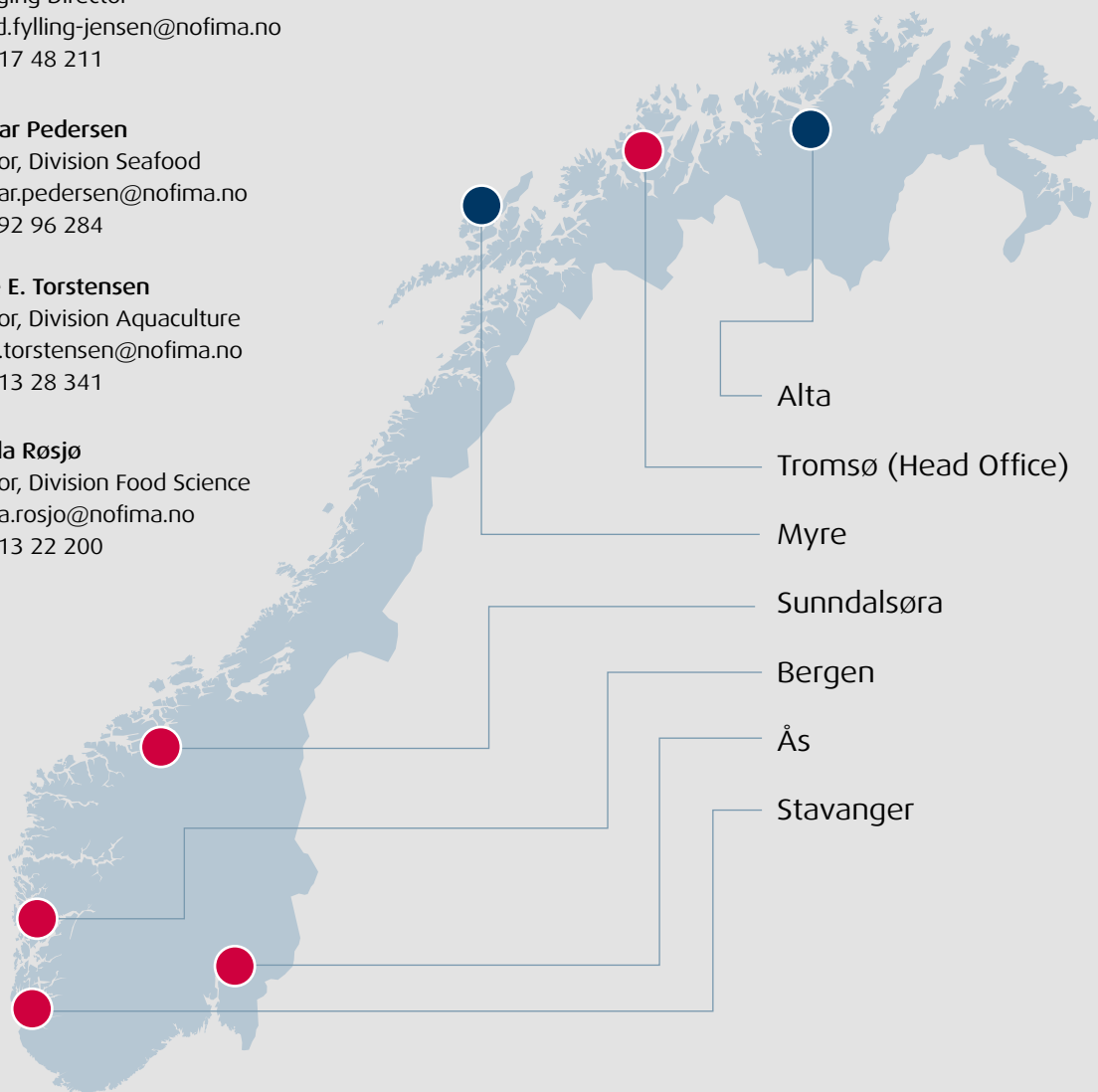
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