ANNUAL REPORT
2023

FOODS OF NORWAY

FOODS OF NORWAY AIMS TO FEED FISH AND FARM ANIMALS USING SUSTAINABLE NEW INGREDIENTS.

Foods of Norway is funded by the Research Council of Norway (grant no. 237841/O30), our partners and our host institution - the Norwegian University of Life Sciences (NMBU).

CONTENTS

EXECUTIVE SUMMARY

With eight years of research activities under our belts, Foods of Norway as a centre has now reached many milestones and documented a lot of exciting results. Thanks to the dedicated partners in the centre and its many talented researchers and technicians, we have been able to continue our path toward more sustainable feed resources for fish and livestock.

A major milestone was reached with successful large-scale production of yeast grown on spruce sugars. The yeast was used in two large-scale feeding trials: one with salmon in seawater and one field trial with piglets. Salmon reared under commercial-like conditions fed diets with up to 12% yeast supported high growth performance, health and welfare and product quality. Similarly, feeding diets with 8% yeast to piglets under field conditions supported high growth performance, health and welfare.

Increasing cost of sugars derived from spruce trees and nitrogen sources in recent years has made the production of yeast as a feed ingredient more challenging. To reduce costs, the focus has turned towards the mycoprotein PEKILO®, which can utilize cheaper side-streams from spruce trees. Two trials with Atlantic salmon showed that fish fed PEKILO® perform well and that the PEKILO® resulted in a strong dose-dependent immunomodulating effect. We are optimistic about using PEKILO® as a high-quality sustainable protein source in feed for fish and farm animals.

Evaluating the potential of seaweed as a feed resource is also a major part of our research. In 2023, we have shown that the use of fucoidan extracted from sugar kelp during sea water transfer improved growth performance, health and robustness of Atlantic salmon. This suggests that fucoidan is an interesting candidate for functional feeds. We have also found that feeding diets with seaweed to dairy cows resulted in higher feed intake and milk yield, and milk with higher fat and iodine content. Foods of Norway continues working on validating stable isotopes as a selection criterion for a more feed- efficient salmon. The centre has also contributed to validating new feed ingredients using sustainability analysis.

One PhD student, Martine Andrea Olsen, successfully completed her degree this year on the effect of feeding yeast to cows on milk yield and quality of dairy products compared to when feeding soy.

Foods of Norway has built up recognition in the media and with authorities and interest groups as a valuable knowledge provider. Foods of Norway was invited to an expert group for the government's societal mission on sustainable feed to provide advice and technical input on how to design the mission.

Another important event in 2023 was that Foods of Norway was awarded its own postage stamp. Norway Post and the Research Council of Norway wanted to honor the centre's successful work in developing sustainable feed resources.

We are looking forward to continuing our work in 2024, which will give us opportunities to fulfill our goals and ambitions.

Centre Director,
Professor Margareth Øverland

Margareth Øverland

VISION AND OBJECTIVES

The Foods of Norway vision is to increase value creation in the Norwegian aquaculture, meat and dairy industries by developing novel feed ingredients from natural bioresources and by improving feed utilization.

The main objective of Foods of Norway is to make Norwegian fish and animal farming industries more competitive and innovative by developing novel feed ingredients from bioresources and ensuring efficient feed resource utilization.

The secondary objectives are to:

- **EXPLOIT** modern biorefining technologies to develop high-value feed ingredients from lignocellulosic biomass.
- **USE** innovative bioprocessing to develop novel feed ingredients from local natural bioresources such as macroalgae and animal and plant co-products.
- **IMPROVE** efficiency of existing feed resources through innovative bioprocessing.
- **ALLOCATE** feed resources across species (fish, pigs, broiler chickens and dairy cows) for optimal production economy and minimal environmental impact.
- **PROVIDE** knowledge to ensure that the novel feed ingredients support production of high-quality Norwegian food products.
- **IDENTIFY** biomarkers for optimal utilization of novel feed resources for use in future fish and animal breeding programs.

RESEARCH PLAN

The Norwegian fish-farming and livestock industries rely heavily on imported protein-rich feed ingredients, such as soy-based products. Heavy use of such ingredients raises some ethical concerns, however, as it puts increased pressure on natural resources and leads to greater competition for human food.

The sustainability of future livestock and farmed fish production will depend on increased use of local and novel feed ingredients.

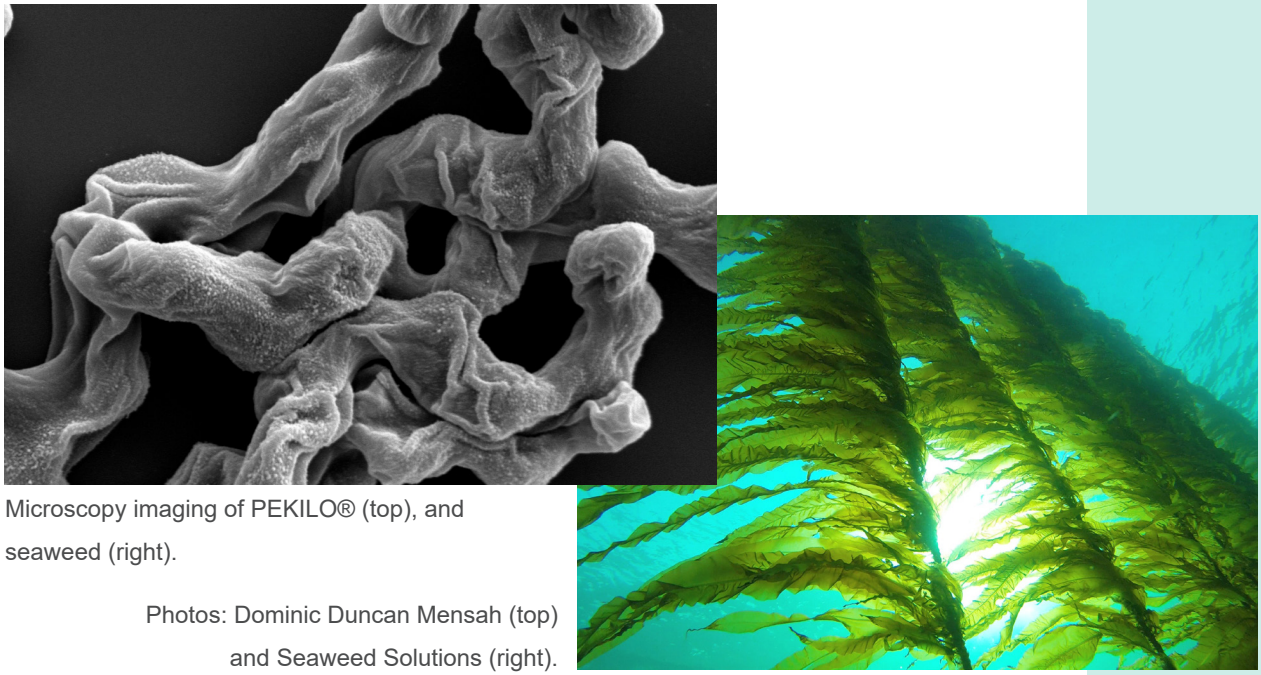
These novel ingredients should have a low environmental impact and should be produced from local resources and waste streams that are not suitable for human consumption. At the same time, we need to use our feed resources more efficiently, for example by genetic improvement of animals and optimal feed resource allocation across species.

Norway has limited land area for cultivating food and feed crops, but possesses considerable natural bioresources such as trees, grass, macroalgae, and by-products from fish, animals and plants. These have great potential as a basis for producing novel feed ingredients.

Foods of Norway develops sustainable feed ingredients from selected renewable bioresources which are available in sufficient quantities to support large-scale production at a competitive cost.
The centre consists of six integrated work packages with several sub-tasks, each led by an NMBU researcher and in close collaboration with our industry partners. The research is multidisciplinary and there are close synergies across the work packages.

Trials with salmon fed yeast at LetSea's fish farm at Dønna (top), and broilier chicken fed a yeast-based diet (right).

Photos: Margareth Øverland (top) and Wiki Commons (right).



Microscopy imaging of PEKILO® (top), and seaweed (right).

Photos: Dominic Duncan Mensah (top) and Seaweed Solutions (right).

The research plan for the last year in the centre (2024) will focus on evaluating microbial ingredients such as the mycoprotein PEKILO® that have a higher protein content and can grow on cheaper forestry-based side streams than yeast. Researchers in the centre are studying the nutritional value and beneficial effects on health, as well as sustainability and techno-economical properties of these microbial ingredients.

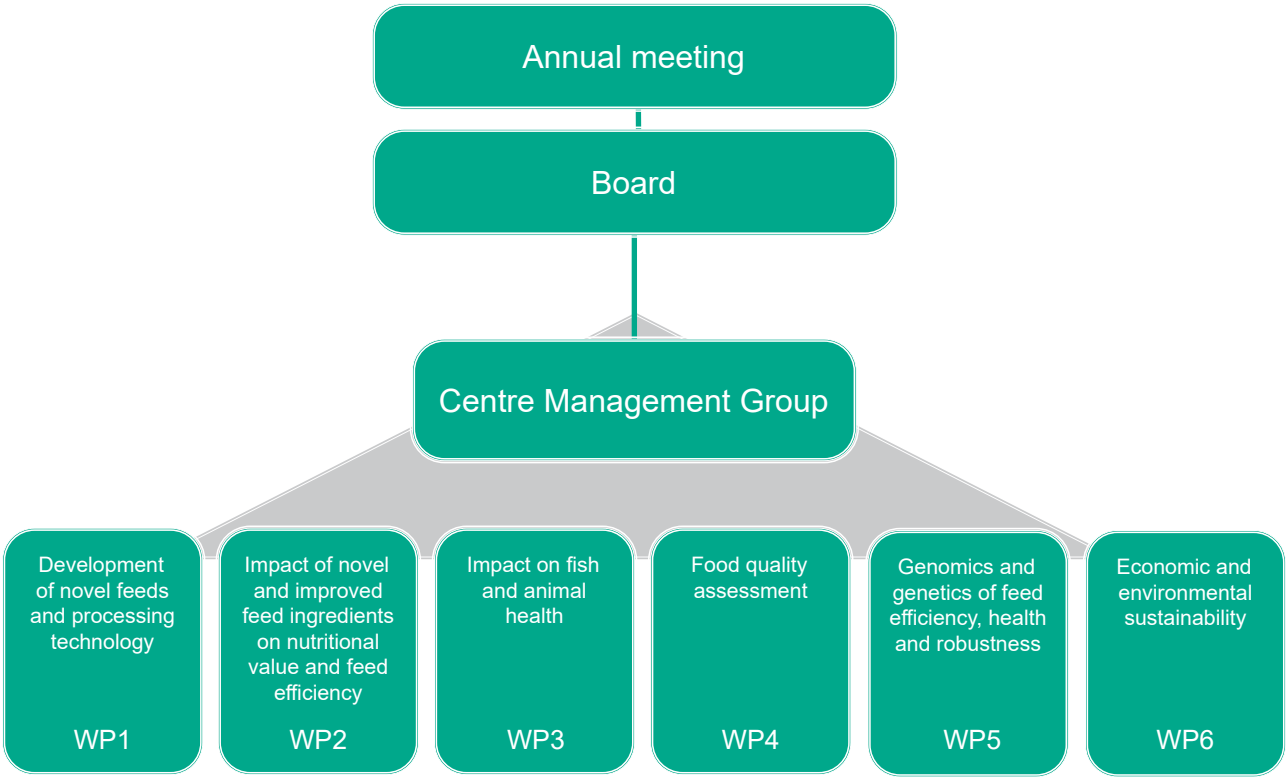
Foods of Norway researchers are investigating low-processed seaweed (sugar kelp) as a functional ingredient to improve the meat quality of beef cattle and yield and quality of milk from dairy cows. Fucoidan, extracted from sugar kelp, is evaluated in functional feeds for Atlantic salmon and broiler chickens with focus on immunomodulating properties and gut microbiota composition to improve health and robustness. Different technologies are being evaluated to preserve the nutritional value and functional properties of seaweed during storage.

Foods of Norway has a special focus on improving the feed efficiency and robustness of farm animals and fish. Improvements in feed efficiency have a large impact on feed resource utilization, feed costs and the environment. We have developed novel indicator traits for individual feed efficiency in salmon, based on stable isotope profiling. By using natural isotopes, phenotyping is applicable in practice. Over the next year there will be a final verification experiment with large salmon. Also, we will assess whether the indicator traits can be applied to dairy cows and pigs.

ORGANISATION

The Board is the ultimate decision-making body of the Consortium. The board's main responsibility is to ensure that the intentions and plans underlying the contract for the establishment of the centre are fulfilled.

The centre director is in charge of the operation of the centre, assisted by the centre management group that consists of the centre director, the work package leaders, centre coordinator and administrator. The Annual Meeting convenes once a year.



THE BOARD

Vegard Denstadli

Chair

BioMar

Kari Kolstad

Deputy chair

NMBU / Research Department

Eirik Selmer-Olsen

Member

Tine

Hege Rivedal-Ødegaard

Member

Denofa

Cecilie Hultmann

Member

Nortura

Bjørg Heringstad

Member

Geno

Gudbrand Rødsrud

Member

Borregaard

Solveig Fossum-Raunehaug

Member

NMBU / Research Department

Sigrid Gåseidnes

Member

NMBU / Faculty of Chemistry, Biotechnology and Food Science

CENTRE MANAGEMENT GROUP

Margareth Øverland
Centre Director

Professor, NMBU
Faculty of Biosciences

Svein Jarle Horn
Leader WP1

Professor, NMBU
Faculty of Chemistry, Biotechnology and Food Science

Liv Torunn Mydland
Leader WP2

Professor, NMBU
Faculty of Biosciences

Charles McLean Press
Leader WP3

Professor, NMBU
Faculty of Veterinary Medicine

Siv Borghild Skeie
Leader WP4

Professor, NMBU
Faculty of Chemistry, Biotechnology and Food Science

Gunnar Klemetsdal
Leader WP5

Professor, NMBU
Faculty of Biosciences

Hanne Fjerdingby Olsen
Leader WP6

Postdoctor, NMBU
Faculty of Biosciences

PARTNERS

The Foods of Norway consortium comprises three faculties at NMBU and 20 partners in industry and innovation. We also work closely with several international partners and collaborators.

Supporting partners

NORGES BONDELAG

NORSK LANDBRUKSSAMVIRKE

NHO Mat og Drikke

Innovation Norway

Academic partners and collaborators

Norwegian University of Life Sciences

SLU

AARHUS UNIVERSITY

THE UNIVERSITY OF WESTERN AUSTRALIA

UNIVERSIDAD DE CHILE

UNIVERSITY OF COPENHAGEN

USDA

UNIVERSITY OF MINNESOTA

Academic partners

- NMBU's faculties of
  - Biosciences
  - Chemistry, Biology and Food Science
  - Veterinary Medicine
- University of Copenhagen

International collaboration

- Aarhus University
- Swedish University of Agricultural Sciences
- University of Minnesota
- University of Western Australia
- University of Chile
- US Department of Agriculture (USDA - ARS)

Industrial partners

- Animalia
- AquaGen
- BioMar
- Borregaard
- Denofa
- enifer
- Felleskjøpet Fôrutvikling
- Geno
- Lallemand
- Norilia
- Felleskjøpet Agri
- Norsvin
- Nortura
- TINE
- Viken Skog
- Seaweed Solutions

Supporting partners

- Innovation Norway
- NHO Mat og Drikke
- The Federation of Norwegian Agricultural Cooperatives
- The Norwegian Farmers' Union

Photo: Shutterstock

COOPERATION BETWEEN PARTNERS

In a centre for Research-based Innovation (CRI), industry participation is very important. Foods of Norway collaborates across three sectors – agriculture, aquaculture and forestry.

The aim is to promote discussion and close collaboration, leading to new research ideas and innovation potential across the sectors. To achieve this collaboration, Foods of Norway hosts joint partner meetings and frequent meetings between academia and industry partners. In June 2023, a partner meeting was held to present the recent research and activities in the centre. A group-work session was organized to discuss how to meet the mission of our government on sustainable feeds.

Two trials with the microbial protein source PEKILO® for Atlantic salmon were conducted in 2023 in cooperation with the NordicFeed project. Borregaard provided the forestry-based side stream, sulphate stillage from their bioethanol process, as a substrate for the fermentation, while the fermentation to produce PEKILO® was done by enifer.

After the successful industrial scale-up of yeast produced from sugars from Norwegian spruce trees, and the evaluation of yeast in two large-scale feeding trials in 2022 in collaboration with NMBU and the industrial partners BioMar and Felleskjøpet Fôrutvikling, samples to evaluate health effect of feeding yeast-based diets have been analysed, and statistical analysis of results have been made and two publications are under development.

Trials with blanched brown seaweed (sugar kelp) in diets for beef cattle have been conducted in collaboration between Nortura, Seaweed Solutions, Felleskjøpet Fôrutvikling and NMBU. Results showed that functional feeds containing seaweed improved the meat quality in terms of decreased cooking loss and increased level of iodine and selenium in the meat. A trial with seaweed in diets for dairy cows in collaboration with TINE, Seaweed Solutions, Felleskjøpet and NMBU showed that seaweed increased feed intake, milk yield, milk fat content and energy corrected milk yield with no adverse effect on sensory quality of the milk.

TINE and NMBU have been working on increasing the nutritional value of grass. In 2023, samples from a trial with late-harvested grass, where different enzyme cocktails were added to increase the digestibility of the grass, have been analysed.

The methods developed by scientists from NMBU and AquaGen on improved feed efficiency in salmon will be validated in an experiment with large salmon before the method can be included in AquaGen's breeding program. In collaboration with Norsvin and Felleskjøpet Fôrutvikling, NMBU will start a project on stable isotopes on pigs, with the aim of utilizing the methodology to improve the feed efficiency of crossbred pigs, but also as a new method for feed evaluation.

The collaboration model will continue to drive Foods of Norway's activities to ensure innovation and commercialization.

INTERNATIONAL COOPERATION

Foods of Norway continued to work closely with several of our international collaborators in 2023

International collaboration results in important knowledge. Foods of Norway has three international partners: the University of Copenhagen (UC), the Canadian company Lallemand, and the Finnish partner enifer. In 2023, collaboration with UC has mainly been through publishing a manuscript based on an experiment with yeast as a protein source in diets for broiler chickens. The collaboration with Lallemand includes evaluating results from field trials with yeast in diets for Atlantic salmon and piglets on growth performance, health, welfare and sustainability.

The Finnish start-up company enifer has produced a microbial ingredient (PEKILO®) from forestry side streams that was used in experiments with Atlantic salmon focusing on nutritional value and health benefits. The diets for these trials were produced at the Swedish University of Agricultural Sciences (SLU).

There has been collaboration with Aarhus University on the publication of results from an experiment with yeast in diets for piglets on metabolite profile in urine and plasma to seek an in-depth understanding of the metabolic fate of yeast-based diets.

Postdoctoral fellow Purushothaman Kathiresan spent three months at the National University of Singapore, where he carried out proteome analysis on gastro-intestinal samples from Atlantic salmon fed yeast under field conditions, with focus on immunomodulation.

Together with researchers from SLU in Sweden, the centre has organised a full-day workshop on microbial feed ingredients. These are researchers involved in the NordicFeed and ForestFeed projects.

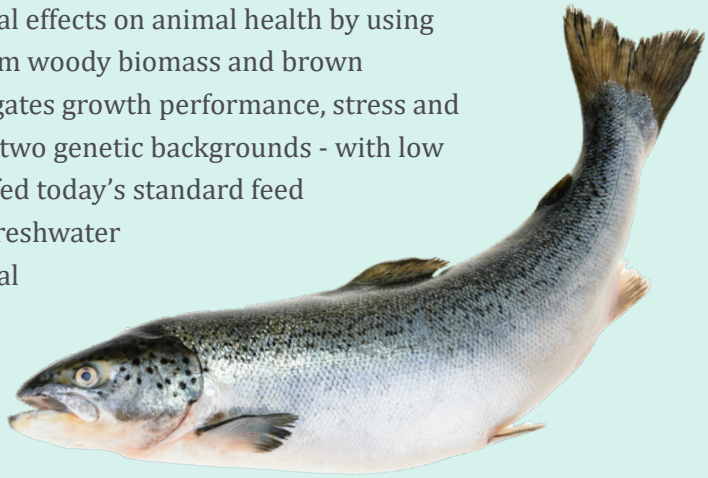
International ongoing spin-off projects

NORDICFEED

NORDICFEED (Bio-conversion of non-food bio-resources to novel feeds for salmonids – a Nordic approach) aims to enhance the performance, health and robustness of rainbow trout and Atlantic salmon in various life stages and environmental conditions. The project's goal is to develop optimized feed formulations based on sustainable microbial feed ingredients from locally available waste streams. International partners: Swedish University of Agricultural Sciences, Natural Resources Institute Finland, Vattenbrukscentrum Norr AB, Sweden, and enifer, Finland.

Resilient Salmon

The project Resilient Salmon (Trained immunity and nutritional programming for resilient salmon) investigates beneficial effects on animal health by using bioactive feed components from yeast from woody biomass and brown seaweeds. Specifically, the project investigates growth performance, stress and health responses in Atlantic salmon from two genetic backgrounds - with low and high levels of resilience. The fish are fed today's standard feed and tomorrow's feed with yeast, both in freshwater and during seawater transfer. International partners are University of Santiago, Chile; Pontifical Catholic University of Valparaiso, Chile; and University of Wisconsin-Madison, USA.



SafeKelp

The SafeKelp project (Safe kelp for food and feed – controlling the transfer of iodine and arsenic through the value chain) aims to follow the presence of iodine and arsenic throughout the value chains from cultivation to human consumption with the aim to manage feed/food safety of this valuable resource. The project focuses on the species Saccharina latissima (sugar kelp) and Alaria esculenta (winged kelp), both cultivated in Norway, and S. japonica, which is cultivated in China. The project is a collaboration between Norwegian (NMBU, Sintef Ocean, Institute of Marine Research) and Chinese partners (Institute of Oceanology, Chinese Academy of Sciences and Yellow Sea Fisheries Institute, and Chinese Academy of Fishery Sciences).

ForestFeed

The ForestFeed project (Bioeconomy in the North - A Nordic blue-green value chain from forest to fish filet) aims to facilitate the bioeconomy in the Nordic region by biorefining side-streams from wood into valuable nutrients, thereby strengthening the forestry and aquaculture sectors. International partners are Swedish University of Agricultural Sciences; enifer, Finland; Institute for Food and Environmental Research, Germany.

RESEARCH HIGHLIGHTS IN 2023

The main goal of Foods of Norway is to develop novel protein sources in diets for livestock and fish. The centre focuses on the use of woody biomass and seaweed, both abundant resources in Norway and which do not compete with resources for human food. This is a sustainable approach to some of the challenges we see in agriculture and aquaculture today.

1 Biomass processing and production of microbial ingredients

In Foods of Norway, enzyme technology and fermentation processes are used to produce microbial biomass from underutilized bioresources as a novel feed ingredient for the aquaculture and agriculture industries.

A novel pathway for improved value creation of our natural bioresources is to develop processes to convert these into microbial ingredients, such as yeast. Developing these processes and documenting the use of yeast as a novel protein source in animal feeds are some of the centre's main areas of research.

The fermentation research focus has moved from yeast to filamentous fungus (PEKILO® mycoprotein), and procedures to grow fungi in bioreactors have been successfully established.

The centre has also been working to improve the nutritional value of grass silage. Samples of late-harvested grass, where different enzyme cocktails were added to increase the digestibility of the grass, have been analysed.

Foods of Norway aims to improve nutritional value of grass silage.

Photo: Foods of Norway

2 Testing the impact of novel feed ingredients

Foods of Norway evaluates novel feed ingredients for nutritional value, growth performance and the health of livestock and fish, and the quality of fish, meat and milk products.

Yeast as a feed ingredient

Yeast in diets for salmon and piglets have been evaluated in two large-scale feeding trials. BioMar carried out the salmon trial in seawater where the fish were fed diets with 0, 6, 12 and 18% yeast. Results show that salmon fed diets with up to 12% performed well, they had high growth performance, good health and welfare and product quality. Felleskjøpet Fôrutvikling performed the field trial with piglets that were fed a diet with 0 or 8% yeast. The yeast-based diet resulted in high growth performance, as well as good health and welfare.

Trials with salmon (top) and piglets (right) fed yeast grown on spruce sugars.

Photos: BioMar (top) and Foods of Norway (right)

Evaluation of nutritional value and health effects of PEKILO®

The centre has been evaluating the mycoprotein PEKILO® produced by enifer using a side-stream from Borregaard in two trials with Atlantic salmon. One trial focuses on growth and feed utilization and the other on health effects when transferred into seawater. Results showed that salmon fed PEKILO had high feed intakes, grew well, and utilized the nutrients in PEKILO® well. Feeding a PEKILO®-based diet also had a positive dose-dependent effect on immunomodulation and gut morphology, suggesting a positive effect on health.

Evaluation of brown seaweed as a functional feed ingredient

The centre has shown in 2023 that the use of fucoidan, a bioactive component extracted from sugar kelp, in functional feeds during seawater transfer improved growth performance, health and robustness of Atlantic salmon. The results suggest that fucoidan is an interesting candidate for functional feeds, but the effect depends on the processing method and inclusion level.

A trial with low-processed brown seaweed (sugar kelp) in diets for beef cattle have been conducted. The cattle were fed a total mixed ration of silage, concentrate and 1% blanched sugar kelp on a dry matter basis. Results showed that seaweed improved the meat quality with respect to increased tenderness and iodine level in the meat.

Saccharina latissima - or sugar kelp.

Photo: Foods of Norway

3 Genomics and genetics

Methods for direct selection for improved feed efficiency based on individual metabolic efficiency have been developed.

The centre has developed a method to select salmon with increased feed efficiency. The method is to use natural isotopes in feed for the property to be analysed in slaughter tests. This has been evaluated in rainbow trout, and a validation experiment with large salmon will be conducted. After completing the validation experiment with large salmon, the method can be included in AquaGen's breeding program from 2025 onwards.

NEW SPIN-OFF PROJECT IN 2023

One spin-off project was granted funding in 2023:

Interdisciplinary research to ensure the availability of quality water and food, generating, transferring knowledge and solutions that promote entrepreneurship and sustainable water management of micro, medium and small-scale biointegrated agro-aqua-culture systems.

The project is a collaboration among three institutions: UCN, Chile (project leader); NMBU, Norway; and UU, Turkey on three UN SDGs: zero hunger (2), responsible production and consumption (12) and collaborate on reaching the goals (17). NMBU will transfer knowledge on developing high-quality sustainable feed resources based on upcycling natural resources and side streams from forestry and agriculture with biorefinery processing from ongoing research at Foods of Norway and spin-off projects. This will be done by organising courses and workshops in sustainable aquaculture, circular economy, and feed and food security toward academia, industry, policy makers and social media. The global aquafeed company Biomar will also collaborate.

ARTICLES

Cheese from cows fed local protein sources is just as good!

(source: nmbu.no)

The quality of cows' milk and cheese will be just as good even if the Brazilian soy is replaced with locally produced ingredients. Norwegian spruce can be turned into proteins in the concentrate.

Martine Andrea Olsen has completed her PhD thesis at NMBU on how a more sustainable feed for dairy cows affects milk and cheese quality.

Photo: Aleksander Benjaminsen

Spruce becomes yeast, and the yeast becomes part of the concentrate. Martine Andrea Olsen has in her PhD work at NMBU and Foods of Norway studied how the locally produced feed affects the cheese quality.

Clear answer

It is not often that researchers can answer as clearly as Olsen does to the question of whether feed with yeast is good enough for both the cow and the cheese factories: "The main purpose was to see if we can replace soy with yeast. And we can," she says.

To produce milk and cheese of good quality, the cow needs proteins in the diet. If imported soy in the concentrate feed can be replaced with Norwegian raw materials, it is good for both sustainability and self-sufficiency.

Martine Andrea Olsen's specialty is the cheese, not the feed or the cows.

"The feed must be developed and produced. Then the cow must be happy with the feed, and then I am the one who can see how it affects the production of the cheese. It doesn't help to have feed that is sustainable and can be produced in Norway if it doesn't produce milk and cheese of good quality," she explains.

Sugar becomes yeast

That is why she has tested what happens to milk and cheese when the cow has been fed with three different protein sources. Soy is one. Norwegian barley is the other, but due to its low protein content the cow gives less milk. "The third is a novel protein source that can be produced from Norwegian spruce trees," she says. The process is a bit more complicated. You break down the cellulose in the tree so that it turns into sugar. This sugar is used to grow yeast cells, and it is this yeast that contains proteins."

No difference

The result is therefore promising: "Considering the production and quality of cheese, we can replace soy with yeast," she states.
"The cow did not react differently to the feed either: It tastes the same, and we noticed no differences when examining the health of the cows," she says. Thus, it is the economy that decides when the concentrate can become fully Norwegian. One of the partners in the project, Borregaard, even has a plant that can be used to produce sugar. Another partner, Lallemand, has used this sugar to produce larger quantities of yeast for feed.

Cows liked the yeast-based feed and their milk yield was similar to that of the animals fed the soy diet.

Photo: Foods of Norway

Is it worth it?

It is still expensive to produce yeast this way. But the researchers continue to work on using such ingredients in the feed. They are also looking at ways to make production cheaper.
The consumers, who are going to drink milk and eat cheese, do not notice the difference between yeast and soy in the feed, and neither does the cow. At the cheese factory, it is the protein content that affects the cheese-making efficiency, and there is not much of a difference between yeast and soy in the feed. The end product – the cheese – will be the same anyway.

Foods of Norway on a postage stamp

(source: nmbu.no)

The researchers at Foods of Norway have developed sustainable feed resources, and this is something Norway Post, together with the Research Council of Norway, wanted to honour with a special postage stamp. The launch took place in the library at NMBU on 28 September.

Foods of Norway was honored with its own postage stamp. From left: Mari Sundli Tveit, Halvor Fasting, Margareth Øverland and Siri Fjellheim.

Photo: Janne Brodin

Rector Siri Fjellheim expressed her gratitude to Norway Post and the Research Council of Norway for making Norwegian research visible through the stamp series “Research, innovation and technology”.

“Research and knowledge are key to the success of the necessary green deal and a sustainable transformation of society,” the rector said. “It doesn’t help to have excellent research if it is not visualized and used. And one might ask whether a visibility of 2 x 3 centimetres is important, but I think so. And this is true even in our digital world, because postage stamps are still part of our national identity.”

The rector applauded the researchers at Foods of Norway. She boldly made the claim that the Norwegian government might not have set the goal that all feeds shall be produced from sustainable resources by 2030 if it had not been for Foods of Norway.

The rector concluded by saying that the stamp is a tribute to cooperation, hard work, and curiosity. “Cutting-edge basic biotechnological research on enzymes,

for example, combined with bioscience and veterinary research over many years, forms the basis of Foods of Norway."

The floor was then given to Halvor Fasting, Director of Stamps at Norway Post, who welcomed the invitation to launch a new stamp in the "Research, Innovation and Technology" series.

The Foods of Norway stamp is number 2,103 in the series. And even though the use of stamps has declined, a total of 15 million stamps was sold in 2022. Many of the 15,000 stamp collectors in Norway look forward to adding the new stamp to their collection.

"And the stamp is more than just a stamp. It should reflect a country's history, nature, and culture, reminding us of the great events, personalities, and anniversaries. So, I like to say that the postage stamp is a country's business card," said the stamp director.

The "Research, Innovation and Technology" series was launched in 2020 to highlight organisations and projects within Norwegian research, technology, and innovation.

Mari Sundli Tveit, Director of the Research Council of Norway (RCN), talked about how the collaboration with Norway Post on this series started. "It was a very good initiative, and it's wonderful that we can use these miniature visualizations of great examples of research and innovation in Norway. To end up on a stamp has always been a seal of quality and a great honour, and one that very few achieve.

"And it is an expression of success, not just for Foods of Norway's research group and what you do, but that you have achieved something of national significance," said Tveit. She said that the work of Foods of Norway is world-class. "It will be of huge importance for Norwegian value creation in the future, for sustainability in practice by building the new value chains, and for ensuring that our livestock both on land and at sea have access to sustainable feed."

Centre director Margareth Øverland unveiled the postage stamp.

Photo: Janne Brodin

Tveit made it clear that, as RCN director, she had not been involved in the selection process but had supported the choice when the Foods of Norway proposal was put forward.

At the close of the event the Foods of Norway stamp was unveiled and centre director Margareth Øverland presented in brief what Foods of Norway has achieved.

The best of two (Norwegian) worlds

(source: nortura.no)

For more than eight years, Foods of Norway has been studying the effect of seaweed in livestock diets. The first results show good effects on taste and quality.

Feeding sugar kelp to beef cattle improved meat quality with respect to tenderness and iodiine level in meat.

Photo: Benjamin Fjerdingstad

Positive results of seaweeds

The first results from the project were presented in October 2023 and are exclusively positive. The biggest effects are seen in the quality of the meat, which became more tender and a fresher red color. In addition, the meat had better storage quality, reduced cooking loss, and a higher level of antioxidants, selenium and iodine that are naturally found in seaweed. These effects were more evident in lamb than in beef. In addition, a consumer test showed that the lamb had a more salty and spicy taste, which was perceived as positive and better by the test panel. The lamb also had a higher nutritional content through higher levels of iodine and selenium. In addition, the kelp contains several bioactive substances that have a positive effect on the health of the animals, and they seemed to enjoy the taste since they ate the feed well.

“Not many people know that in the past, seaweed and kelp were often used as feed in years where access to feed was low. This is how many of the seaweeds got its name,” says Margareth Øverland.

She is centre director of Foods of Norway, a centre for research-based innovation that is investigating methods and technology to increase the use of seaweed in diets for both farm animals and fish.

Cattle and small ruminants give unique opportunities

Since the centre started in 2015, Øverland has tested seaweed (sugar kelp) in diets for several animal species, from farm animals to fish. In October 2023, the first results from trials on lamb and beef cattle were published.

"The kelp is easier for cattle and small ruminants to eat untreated due to the rumen fermentation, and therefore gives us unique opportunities to serve the feed without any processing beforehand." says Øverland.

Beef cattle fed sugar kelp.

Photo: Margareth Øverland

The kelp from the lamb trial was harvested in June, chopped and then frozen before being transported to NMBU in Ås. Here, the conditions were good for sun-drying the kelp, which was then mixed with concentrate and forage. The feed was given to a test group of lambs over five weeks before slaughter. In the experiment with cattle, the animals were fed the same type of kelp for almost seven weeks before they were slaughtered.

An important part of the goal of increasing the Norwegian share in animal feed

The research project is part of Nortura's goal to increase the Norwegian-produced share of the total amount of feed for livestock up to 100% by 2030.

"This project is completely in line with Nortura's sustainability strategy and gives us positive effects in several areas. This increases the share of Norwegian feed, which is good for the climate and food security. In addition, we get positive effects on meat quality, shelf life and taste, which is positive for the consumer. And finally, the project is based on Norwegian value chains from the cultivation of the kelp to edible meat. This is good for Norwegian industry and local jobs," says Cecilie Arnesen Hultmann, head of sustainability at Nortura and board member of Foods of Norway.

KNOWLEDGE SHARING

Foods of Norway scientists are frequently invited to scientific meetings and conferences, often as keynote speakers or panel participants, and to meetings with stakeholders from the aquaculture, forestry and agricultural industries, as well as with politicians and regulatory authorities.

In 2023, Foods of Norway researchers gave talks at several important scientific conferences around the world. A group from the centre went to Inderøy in Norway for the 2nd Seaweed Applications conference in March. Several of the scientists travelled to Vienna, Austria, to present their work at the Aquaculture Europe 23 Conference in September. Other participation includes contributions from the centre at the EAAP conference in Lyon, France, and ICoMST2023 in Padova, Italy.

The Foods of Norway delegation in Vienna, Austria.

Photo: Foods of Norway

Centre director Margareth Øverland participated in several events on behalf of the consortium. She was a speaker at IFFO annual meeting in Madrid, at a conference on sustainable feed in Oslo, and at AquaNor in Trondheim. She was a speaker at a seminar at IDiBE in Elche, Spain. Professor Øverland also participated in several major Norwegian events looking at novel feeds in the blue and green sectors.

Workshop on microbial feed ingredients, organised by Foods of Norway and the projects NordicFeed and ForestFeed.

Photo: Ingjerd Dønnem

The centre hosted a workshop on microbial feed ingredients together with the NordicFeed and ForestFeed projects in September. In January, the centre arranged a breakfast seminar with the title: What to feed salmon tomorrow? Foods of Norway is working on the menu.

COMMUNICATION AND DISSEMINATION

Foods of Norway's research and innovations are continuously highlighted by domestic and international media, and in 2023 the dissemination of news was the result of both reactive and proactive communication activities.

The centre has had well deserved attention in the media. During the autumn there was a lot of media coverage in connection with the launch of Foods of Norway's own postage stamp. International media have published articles about the research on PEKILO® as feed for farmed salmon. Proactive communication efforts from the centre also resulted in articles in relevant news outlets.

In many of the centre's communication activities during 2023, cooperation between partners has been central and has strengthened both message and delivery, adding value to the centre as a knowledge provider.

The centre's communication strategy going forward is to continue to focus on main target audiences: decision and policy makers, farmers' associations, other stakeholders, and the general public in Norway. The centre also aims to continue building the brand as a knowledge provider for feed and food industries as well as agriculture and aquaculture industries in Norway and abroad.

Article in Khrono 29 September 2023

NMBU og NTNU får egne frimerker

I fire år har Posten hatt en frimerkeserie gående med søkelys på norsk forskning, innovasjon og teknologi.

Frimerkedirektør Halvor Fasting og professor og leder for Foods of Norway, Margareth Øverland, avduket denne uken et nytt frimerke på NMBU. Foto: Posten

Tekst:
Joar Hystad
joar.hystad@khrono.no

Publisert Fredag 29.09.2023 - 08:43 Oppdatert Fredag 29.09.2023 - 12:22

Frimerkeserien er et samarbeid mellom Posten og Norges

Vil over på alternative fôrproteiner innen ti år

Skal nye bærekraftmål nås, må alternative proteinkilder til husdyr kraftig og raskt oppskaleres. Fagfolk, politikere og næringsaktører er enige om at det blir en hovedutfordring.

PROTEINKILDER

Ønsker fellesfront for alternativt fôr

NMBU-professor Margareth Øverland forventer aktiv kunnskapsbruk, pengepåfyll og fagsamarbeid dersom alternative proteinkilder skal bli produsert i store nok volum til å brukes i husdyrnæringene.

PROTEINKILDER

Article from Bondebladet 19 May 2023

news.cision.com / San Francisco Oy / New study by Enifer and NMBU sh...

New study by Enifer and NMBU shows that farmed fish grow better and healthier with fungi produced from Nordic forestry by-products than with soybeans

THU, OCT 26, 2023 08:00 CET

Report this content

As the global demand for fish consumption continues to surge, fish farmers are constantly looking for ways to improve their cultivation techniques. A new study conducted by researchers at the Norwegian University of Life Sciences (NMBU) shows that ary PEKILO®Aqua mycoprotein had a significant positive impact on salmon's natural immune system and

ber 26th, 2023) Finnish biotech startup Enifer has contributed to a new study on farmed salmon that ation with the Norwegian University of Life Sciences (NMBU). The study utilized Enifer's PEKILO®Aqua was conducted by a group of researchers led by Professor Margareth Øverland. The study shows that ing in freshwater fed with PEKILO®Aqua mycoprotein had a significant activation in their immune ter as the feed was more efficiently converted into the fish.

studies carried out at NMBU show that our PEKILO®Aqua mycoprotein not only provides fish with protein, ar added benefits to fish health and growth compared to conventional proteins like soya. These benefits composition of our fungal protein. The fact that PEKILO®Aqua can be produced sustainably, competitively armers makes it particularly attractive to industry. In this study, we used Norwegian forest industry by-eed for Norwegian salmon," says **Joosu Kuivanen**, Chief Operating Officer at Enifer.

Article from news.cision.com 26 October 2023

ATLANTIC SALMON | FEED INGREDIENTS | HEALTH +7 more 26 October 2023, at 7:30am

Study suggests mycoprotein beats soybeans in aquafeeds

A new study conducted by researchers at the Norwegian University of Life Sciences (NMBU) shows that using Enifer's proprietary Pekilo Aqua mycoprotein, which is produced from Nordic forestry by-products, has a significant positive impact on the immune system and growth of salmon.

Enifer's CEO, Simo Ellilä

Article from thefishsite.com 26 October 2023

IN NUMBERS: COMMUNICATION OUTPUT IN 2023

1,004
Facebook followers

24
Articles in editorial media

354
Average reach of our Facebook posts

Articles in editorial media	Norwegian	19
	International	5
Facebook	Followers	1,004
	Average reach	354
	Average engagement (post clicks / reactions, comments & shares)	50
Twitter	Followers	454
	Impressions	842

List of personnel 2023

Key researchers	
Name	**Main research area**
Margareth Øverland	Centre director; Feed ingredient evaluation
Svein Jarle Horn	Bioprocessing, applied enzymology
Liv Torunn Mydland	Process; feed ingredient evaluation
Charles Press	Veterinary pathophysiology, veterinary immunology
Henning Sørum	Bacteriology, pre-probiotics, microbiota, antibiotic resistance, fish diseases
Siv Skeie	Product quality
Gunnar Klemetsdal	Genetics; nutrition; feed efficiency
Hanne Fjerdingby Olsen	Economics and sustainability

Permanent research staff		
Name	**M/F**	**Topic**
Bjørg Egelandsdal	F	Product quality of meat
Nils Petter Kjos	M	Pig nutrition
Egil Prestløkken	M	Ruminant nutrition

Postdoctoral researchers with financial support from the centre budget		
Name	**M/F**	**Topic**
Vladana Grabez	F	Meat quality, proteomics
Hanne Dvergedal	F	Feed efficiency in fish
Özgun Candan Onarman Umu	F	Gut microbiota
Sergio Da Rocha	M	Microbiology and immunology assessment
Brankica Djordjevic	F	Fish nutrition and health
Ruth Tamara Montero Meza	F	Immunology
Jamie Hooft	F	Feed processing, fish nutrition

Postdoctoral researchers working on projects in the centre with financial support from other sources			
Name	**M/F**	**Funding**	**Topic**
Jørgen Ødegaard	M	NMBU	Genomics of feed efficiency
Byron Morales Lange	M	NFR	Mucosal immunity
Davide Porcellato	M	NMBU	Milk microbiota
Purushothaman Kathiresan	M	NMBU	Fish health
Line Degn Hansen	F	NFR	Fermentation

PhD students with financial support from the centre budget		
Name	**M/F**	**Topic**
Martine Andrea Olsen	F	Influence of feed on milk quality

PhD students working on projects in the centre with financial support from other sources			
Name	**M/F**	**Funding**	**Topic**
Eirin Stork	F	NMBU	Product quality of milk
Mette Hofossæter	F		Animal health
Dominic Duncan Mensah	M	NMBU	Fish nutrition and health

Master degrees		
Name	**M/F**	**Topic**
Sana Javed	F	Filamentous fungi (Paecilomyces variotii) as an alternative sustainable ingredient in diets for Atlantic salmon (Salmo salar) : effects on pellet quality, growth performance, nutrient digestibility and utilization, and immune-related biomarkers in the distal intestine during the freshwater phase
July Arinez	F	Estimating microbiota effects on feed efficiency

PhD degrees		
Name	**M/F**	**Topic**
Martine Andrea Olsen	F	Cheese-making efficiency affected by protein source in concentrate feed for dairy cows and their αS1-κ-casein genotypes

Visiting researchers				
Name	**Period**	**M/F**	**Affiliation**	**Topic**
Lele Fu	28.02.22-15.02.23	F	Institute of Hydrobiology, Wuhan, China	Health effects of organic acids in fish feed
Chunyu Ge	28.02.22-15.02.23	F	Chinese Academy of Agricultural Sciences, Beijing, China	Insects as an alternative protein source in fish feed
Hung Quang Tran	24.04.23-03.05.23	M	University of South Bohemia, Czechia	Aquaculture nutrition
Luisa Valente	30.05.23-02.06.23	F	Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Portugal	Fish nutrition and novel feed ingredients & solutions
Yannick Pombett	11.09.23-26.11.23	M	University of Valparaiso, Chile	Fish immunal nutrition
Thilini Hettiarachchi	09.10.23-03.11.23	F	University of Peradeniya, Sri Lanka	Fish immunal nutrition

Statement of accounts

Foods of Norway costs 2023 (1,000 NOK)

Host NMBU	Industry partners (Norway)	International partners	Equipment	Total costs
7,404	1,863	75		9,342

Foods of Norway funding 2023 (1000 NOK)

Host NMBU	Industry partners (Norway)	International partners	Research Council	Total funding
1,536	1,863	75	5,868	9,342

Publications list 2023

- Agboola, J., Rocha, S.C., Mensah, D., Hansen, J.Ø., Øyås, O., Lapeña, D., Mydland, L.T., Arntzen, M.Ø., Horn, S.J., Øverland, M. (2023). Efect of yeast species and processing on intestinal microbiota of Atlantic salmon (Salmo salar) fed soybean meal-based diets in seawater. Animal Microbiome, 5:21. https://doi.org/10.1186/s42523-023-00242-y

- Dvergedal, H., Ødegård, J., Galloway, T.F., Klemetsdal, G. (2023). Isotope fractionation in juvenile and large rainbow trout (Oncorhynchus mykiss): Repeatability of stable isotope measures and their relationship to growth rate. Aquaculture 569:739380. https://doi.org/10.1016/j.aquaculture.2023.739380

- Grabež, V., Devle, H.M., Kidane, A.S., Mydland, L.T., Øverland, M., Ottestad, S., Berg, P., Kåsin, K., Ruud, L., Karlsen, V., Živanović, V. and Egelandsdal, B. (2023). Sugar Kelp (Saccharina latissima) Seaweed Added to a Growing-Finishing Lamb Diet Has a Positive Effect on Quality Traits and on Mineral Content of Meat. Foods, 12, 2131. https://doi.org/10.3390/foods12112131

- Grabež, V., Mydland, L.T., Papoutsis, D., Øverland, M., Egelandsdal, B. (2023). Effect of low dose blanched Saccharina latissima in finishing bulls' diet on carcass and beef meat quality traits. Frontiers in Animal Science. Volume 4. https://doi.org/10.3389/fanim.2023.1233244

- Hofossæter, M.E., Sørby, R., Göksu, A.B., Mydland, L.T., Øverland, M., Press, C.McL. (2023). Cyberlindnera jadinii yeast as a functional protein source for Atlantic salmon (Salmo salar L.): Early response of intestinal mucosal compartments in the distal intestine. Fish and Shellfish Immunology, Volume 137. https://doi.org/10.1016/j.fsi.2023.108758

- Itani, K., Marcussen, C., Rocha, S.C., Katherisan, P., Mydland, L.T., Press, C.McL., Xie, Z., Tauson, A.H., Øverland, M. (2023). Effect of Cyberlindnera jadinii yeast on growth performance, nutrient digestibility, and gut health of broiler chickens from 1 to 34 d of age. Poultry Science, Volume 102. https://doi.org/10.1016/j.psj.2023.103127

- Leszek, M., Morales-Lange, B., Montero, R., Mydland, L.T., Horn, S.J., Øverland, M. (2023). Impact of biorefinery processing conditions on the bioactive properties of fucoidan extracts from Saccharina latissima on SHK-1 cells. Algal Research, Volume 75. https://doi.org/10.1016/j.algal.2023.103221

- Olsen, M.A., Ferneborg, S., Vhile, S.G., Kidane, A., Skeie, S.B. (2023). Different protein sources in concentrate feed for dairy cows affect cheese-making properties and yield. Journal of Dairy Science (JDS), Volume 106(8) s. 5328-5337. https://doi.org/10.3168/jds.2022-22662

- Rocha, S., C., Morales_Lange, B.M., Montero, R., Okbayohanese, D., Kathiresan, P., Press, C. McL., Mydland, L.T., Øverland, M. (2023). Norway spruce extracts (NSEs) as bioactive compounds in novel feeds: Effect on intestinal immune-related biomarkers, morphometry and microbiota in Atlantic salmon pre-smolts. Journal of Functional Foods, Volume 111. 105888 https://doi.org/10.1016/j.jff.2023.105888

FOODS OF NORWAY

Annual report 2023

Norwegian Centre for Research-based Innovation

The Research Council of Norway

NMBU Faculty of Biosciences
Oluf Thesens vei 6, Campus Ås
Telephone:+47 67 23 26 00

www.foodsofnorway.net