

**ANNUAL REPORT
2018**

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. 237841/030), our partners and our host institution - the Norwegian University of Life Sciences (NMBU).



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EXECUTIVE SUMMARY

2018 marks one of the most fruitful years in Foods of Norway so far. Several important methods have been developed in close collaboration between the centre's research staff and its industrial partners.

Several key milestones have now been reached that are in line with the overall goals of Foods of Norway to contribute to growth and value creation in the aquaculture, agriculture and forestry industries by developing sustainable feed ingredients. Foods

of Norway has shown that yeast derived from renewable biomass can be used as a high-quality protein source for fish and farmed animals. An important milestone in 2018 was developing protocols to upscale the production of yeast. The upscaling provides valuable experience on how the production of yeast performs under larger-scale conditions and is an important step towards commercialization.

Another 2018 highlight was bringing our new partner Denofa on board, the leading importer and processor of soybeans for animal feeds in Norway. We are extremely pleased to be able to welcome Denofa to our team, especially in light of their expertise in the production of feed ingredients. Denofa will be an excellent supplement to Foods of Norway's work on more sustainable food production.

In 2018, Northern Europe experienced an unusually hot summer. In Norway, the heat caused the most severe drought in 70 years. This had a serious impact on the agricultural sector, with crop yields less than half of normal. This should be a warning that we need to take climate change and food security more seriously. The drought also led to increased media interest in our research. Foods of Norway is increasingly referred to by policy makers, interest groups, the general public and other stakeholders. Our research is often quoted as an example of the development of a bioeconomy in Norway.

Looking ahead, in 2019 we hope to achieve groundbreaking results on methods that can be used in breeding programs to develop more robust and feed-efficient fish. We will also publish important documentation on the CO₂ footprint of the novel feed solutions.

To sum up, 2018 was a fulfilling year for our science and its innovation potential, and we are looking forward with great expectations for 2019 and the years beyond.

Centre Director,
Professor Margareth Øverland



The unusually hot summer of 2018 should be a warning that we need to take climate change and food security more seriously.

Margareth Øverland, Centre Director Foods of Norway

VISION AND OBJECTIVES



Foods of Norway`s vision

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

make Norwegian fish and animal farming industries more competitive and innovative by developing novel feed ingredients from bioresources and ensuring efficient feed resource utilization.

Secondary objectives

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



Today, the Norwegian fish farming and farm animal industries rely largely on imported protein-rich feed ingredients, such as soy-based products. In addition, the use of human food resources as feed ingredients has been questioned, both for ethical and economic reasons.

Sustainability of future farmed fish and animal production will depend on novel feed ingredients.

Novel feed ingredients should be produced from non-food resources and have a low environmental impact. 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. However, Norway possesses large natural bioresources such as trees, grass, seaweed, and co-products from fish, animals and plants that can provide a basis for the production of novel feed ingredients.

Foods of Norway develops sustainable feed ingredients from renewable bioresources that are not suitable for direct human consumption and that have the potential to be produced in large quantities at a competitive cost.

The research plan consists of six integrated work packages with several sub-tasks ([see p. 8](#)). An NMBU researcher leads each work package and the industry partners are well integrated in the work. Research is multidisciplinary with close synergies across work packages.

Foods of Norway will use microbial ingredients such as yeast as a protein source in feed for farmed animals and fish. We produce yeast on a growth medium based on sugars derived from trees and/or seaweed as well as nutrients from chicken, pig and fish co-products.

Novel cultivation technologies for seaweed and new downstream processing methods are being developed. A major task is to upgrade the nutrient value of the seaweed by a biorefinery process to make use of the entire biomass in the fermentation process for the production of yeast and to isolate high-value bioactive components from the biomass.

Foods of Norway has a special focus on improving feed efficiency and robustness of farm animals and fish. Improvements in feed efficiency have a large impact on feed resource utilization as well as on feed costs and the environment.



Downstream processing of yeast at NMBU's biorefinery lab.

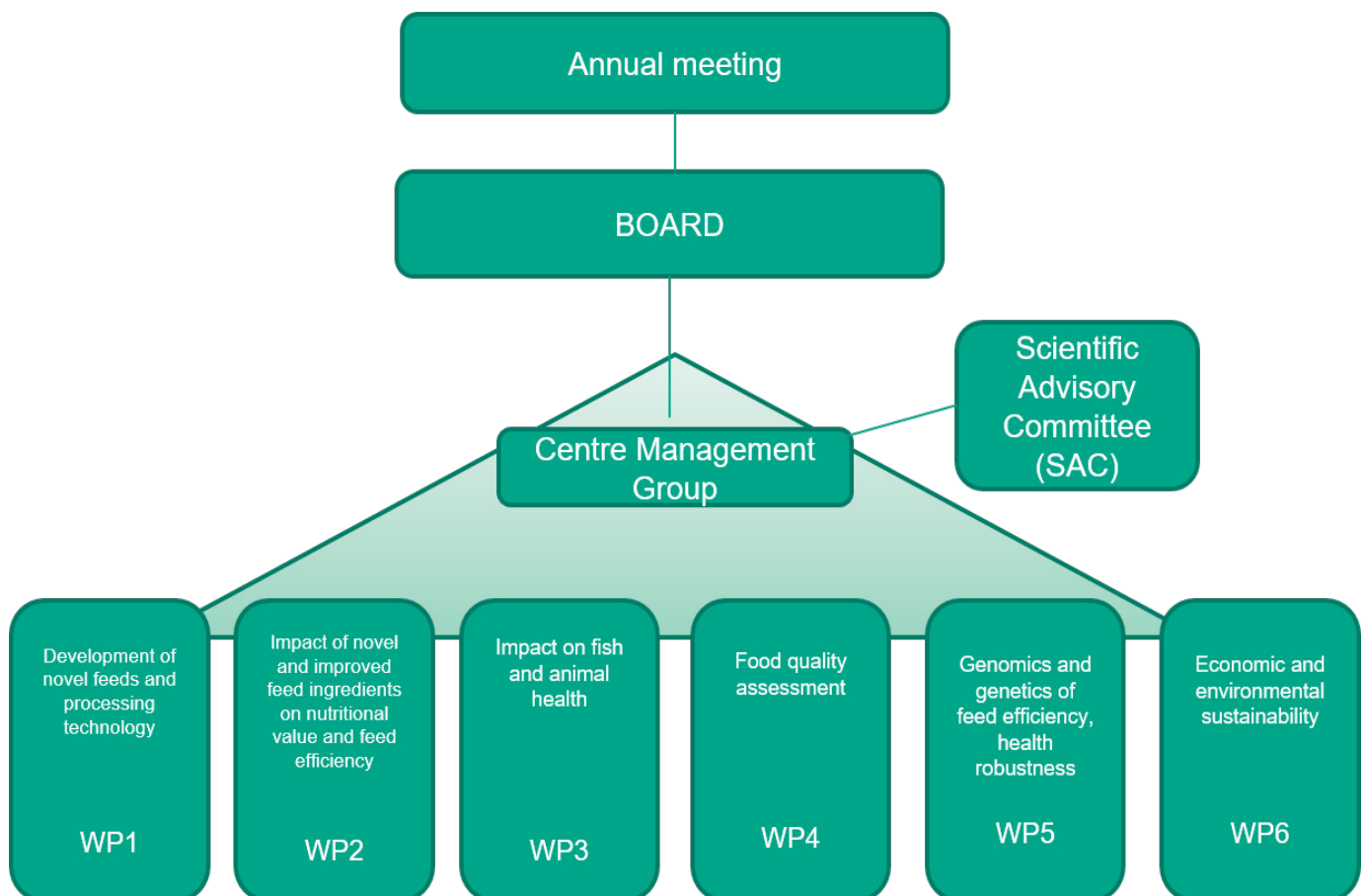
ORGANISATION

The Annual Meeting convenes once a year to discuss the centre's activities, present result highlights from the past year and discuss forthcoming plans.

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.

A Scientific Advisory Committee (SAC) was appointed by the board in 2016 to ensure quality and excellence of the centre's work. SAC has three members: Wendy Rauw, researcher at INIA - Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, in Spain; Birte Svensson, Professor at the Technical University of Denmark, and Anders Karlsson, Professor at the Swedish University of Agricultural Sciences.



THE BOARD



Knut Røflo
Chair

Felleskjøpet Fôrutvikling (FKF)



Ragnhild Solheim
Deputy chair

NMBU, Research Department



Eirik Selmer-Olsen
Member

TINE



Gudbrand Rødsrud
Member

Borregaard



Kari Kolstad
Member

NMBU / Faculty of Biosciences



Morten Sollerud
Member

Norilia



Nina Santi
Member

AquaGen



Ågot Aakra
Member

NMBU / Faculty of Chemistry,
Biotechnology and Food Science

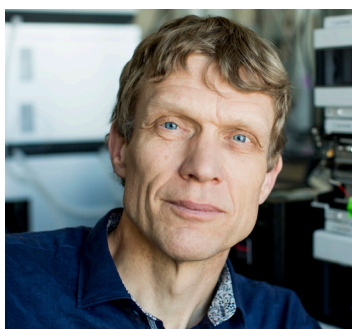
CENTRE MANAGEMENT GROUP



Margareth Øverland

Centre Director

Professor, NMBU
Faculty of Biosciences



Vincent Eijsink

Leader WP1

Professor, NMBU
Faculty of Chemistry, Biotechnology and
Food Science



Liv Torunn Mydland

Leader WP2

Researcher, 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



Gro Steine

Leader WP6

Centre Coordinator, NMBU
Faculty of Biosciences

PARTNERS

The Foods of Norway consortium comprises three faculties at NMBU and 19 partners in industry and innovation. We also work closely with several international partners and collaborators.

Industrial partners	Supporting partners
	
Academic partners and collaborators	
	

Denofa joined the team

Denofa AS, the leading importer and processor of sustainable and non-GMO soy for animal compound feed in Norway, became a partner in Foods of Norway in 2018. Denofa will contribute to the Centre's development of sustainable feed ingredients from local bioresources such as trees and seaweed.

– We are extremely pleased to be able to welcome Denofa on to our team, especially in light of their expertise in the production of feed ingredients. Denofa will be an excellent supplement to Foods of Norway's work on more sustainable food production in Norway, says Centre Director Margareth Øverland.



Photo: Denofa

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

- Agrifirm
- Animalia
- AquaGen
- Borregaard
- Denofa
- Felleskjøpet Fôrutvikling
- Geno
- Norilia
- Norske Felleskjøp
- Norsvin
- Nortura
- TINE
- Viken Skog
- Seaweed Energy Solutions
- Yara

Supporting partners

- Innovation Norway
- Food Drink Norway, Confederation of Norwegian Enterprises (NHO)
- The Federation of Norwegian Agricultural Cooperatives
- The Norwegian Farmers' Union



COOPERATION BETWEEN PARTNERS

As a Centre for research-based innovation (CRI), cooperation with the industry is highly important to Foods of Norway. Our industry partners represent three sectors - agriculture, aquaculture and forestry.

The idea is to engage our partners in discussions that can lead to novel ideas and opportunities for research and innovation across sectors.

Innovation is on the agenda at annual partner meetings and in regular meetings between academia and industry, where researchers are urged to discuss the innovation potential of their research.

In 2018, two joint meetings were organized for the partners in Foods of Norway. At the first meeting, research highlights were presented by PhD students and young scientists. Important topics discussed were:

- Future perspectives – are there any changes that may have consequences for the project?
- Innovation potentials

At the second meeting, we discussed further plans for the centre with special focus on research that is required to commercialize our results.

An internal workshop on seaweed as a feed resource was held in April. The aim was to prioritize further seaweed research in the centre and to plan add-on projects.

During 2018, we achieved closer cooperation between the partners in the centre due to the increase in applied research activities. Examples are presented in the scientific activities and results section in this report.



INTERNATIONAL COOPERATION



During 2018 we worked closely with our international partner University of Copenhagen, and with associated partners in several countries.

Together with the University of Copenhagen, an advanced metabolism trial was carried out by an industrial PhD student who is co-funded by the Norwegian Agricultural Purchasing and Marketing Co-operation (FKF) and the Research Council of Norway ([more on p. 21](#)). The purpose was to assess the impact of increasing levels of yeast in diets for pigs on energy and nitrogen utilization and to measure the environmental impact of the novel feed solution.

The centre also collaborates with the University of Aarhus on evaluating health effects of yeast in diets for piglets by non-targeted metabolomics profiling of plasma and urine. A PhD student from the centre has been visiting Aarhus several times to gain experience on how to analyze and interpret the results.

Foods of Norway has a close on-going collaboration with the Swedish University of Agricultural Sciences (SLU) on optimizing the fermentation conditions for yeast and on finding the most promising yeast strains that grow well on the substrates that are developed in Foods of Norway. In addition, we cooperate with the leading global company in functional feeds, Lallemand. Lallemand provides yeast strains and protocols for fermentation of yeast, and yeast in large quantities for use in studies with pigs, salmon, and dairy cows.

International spin-off projects

Foods of Norway is participating in an ERA-NET, SusPig network (Sustainability of pig production through improved feed efficiency), to share experience and results from research on efficient use of local feed resources for pigs, and how to best assess the implication of these results for the economy, society and environment.

Foods of Norway researchers are also participating in a Nordic Centre of Excellence, SureAqua, on developing novel feed resources for aquafeeds. A PhD student has been employed in order to work with insects as a novel nutrient source for Atlantic salmon. The research is in line with the overall goals of Foods of Norway for the next years.

The centre is collaborating with the University of Minnesota to upgrade the nutritional value of fibre-rich plant ingredients, such as rapeseed meal, by solid-state fermentation technology. The outcome will be important for future work in the centre or in potential add-on projects and will further strengthen the research collaboration with USA as well as Canada.

Salmon collaboration with Chile

In 2018, Foods of Norway collaborated closely with the Pontifical Catholic University of Valparaiso (PUCV) and the University of Santiago in Chile on research related to the impact of yeast on the health of Atlantic salmon and on developing advanced methods to assess health effects of novel feed ingredients.

A guest researcher from Spain`s Centro de Investigación en Acuicultura, Instituto Tecnológico Agrario de Castilla y León (ITACyL) visited the centre from September to November 2018. Her research activity included a fish experiment, and assessing health effects of Atlantic salmon and pigs fed yeast by using several molecular techniques.



RESEARCH HIGHLIGHTS IN 2018

1 Biomass processing and production of yeast

An important task is to find the most suitable yeast strain for use in feeds. In the past years, systematic screening has been done of four yeast strains for fermentation to obtain optimal yield, protein content and functionality.



In autumn 2018 two yeast strains were used in a large-scale fermentation process with growth media consisting of cellulosic sugars from enzymatic hydrolysis of woody biomass from Borregaard, and enzymatic hydrolysates of chicken co-products from Norilia.

In accordance with fermentation protocols developed at NMBU, the fermentation was scaled up from 30 to 200 liters at Borregaard in Sarpsborg. The chicken hydrolysates were produced at NMBU, based on a pre-study in which three types of protein-rich biomasses were evaluated. The upscaling was an important milestone, confirming that the Centre's protocol for production of yeast can be successful on a commercial level ([more on p. 19](#)).

Downstream processing is a major factor determining the nutritional value and functionality of the yeast. To optimize the downstream processing method, baker's yeast was used as a model. The methods included spray drying, cell crushing of yeast by mechanical treatment and autolysis, in which enzymes within the yeast cells break down the cell wall structure. Best performance so far has been achieved through autolysis. The yeast cream produced at Borregaard will be used in further studies to establish superior methods for downstream processing of yeast.

Considerable efforts have also been devoted to processing seaweed during the past year. Results show that hydrolysates from seaweed can be used in the fermentation of yeast. Importantly, this yeast showed promising results as a protein source in a salmon feeding trial.



The successful upscaling of yeast-production at partner Borregaard's facilities in Sarpsborg was one of the major highlights in 2018.



2 Testing the impact of novel feed ingredients

Foods of Norway is evaluating the effect of novel feed ingredients on nutrient digestibility, growth performance, health and food quality of farm animals and fish.

Remarkable results were achieved from a trial with salmon in 2018. The fish were fed a diet with and without 25 per cent yeast during the critical time of seawater transfer. Results showed that the fish fed yeast grew faster and had a healthier gut based on results on the expression of several biomarkers in the gut. This indicates that yeast in the diet improves gut health during the smoltification process and enables the fish to better adapt to saltwater. Our results could have major implications for the aquaculture industry.

A metabolism experiment was performed in 2018 to evaluate the effect of yeast on energy and nitrogen balance in young pigs fed increasing levels of yeast. The experiment was carried out by a Ph.D. student employed at Foods of Norway's industrial partner Felleskjøpet Fôrutvikling (FKF) through the Research Council of Norway's industrial Ph.D. programme, in collaboration with NMBU and the University of Copenhagen. The Ph.D. student also performed a broiler chicken experiment to evaluate the effect of yeast on growth performance, gastro-intestinal health and meat quality. Analyses of tissue and organ samples and statistical evaluations of results from both experiments are underway.

Performing animal studies to assess nutritional value and health effects of feed ingredients is costly and requires large numbers of experimental animals. Thus, for screening purposes, *in vitro* models, mimicking the functions of the digestive tract, can be valuable tools. We have recently established several *in vitro* assays for both monogastric and ruminant animals. These assays will greatly facilitate screening of nutritive value and health effects of the novel feed ingredients developed in Foods of Norway.

In autumn 2018, two experiments were performed to evaluate how the incorporation of brown seaweed in diets for ruminants affects feed intake, growth rate, feed efficiency, carcass quality, gut microbiota and composition, milk yield and composition. For one month, lambs and lactating goats (as a model for dairy cows) were fed diets with 2.5 and 5 per cent cultivated sugar kelp.

The preliminary results are promising with respect to feed intake and growth rate. The experiment was carried out in collaboration with the centre's industrial partners Nortura and Seaweed Energy Solutions (SES).

The novel feed ingredients that we develop in Foods of Norway contain bioactive components such as antioxidants, as well as minerals and vitamins, that can improve the nutritional value of meat and milk products. Novel feed ingredients may also contain contaminants. To gain a deeper understanding of how these feed ingredients influence product quality, we have developed several advanced methods to analyze the meat from salmon, chicken, pig and lamb, focusing in particular on sensory properties, oxidation stability, content of positive and negative flavour compounds and fatty acid composition.

Foods of Norway aims to document the effect of yeast as a feed resource on health and resistance to disease during critical life stages, such as seawater transfer of salmon and weaning of piglets. In autumn 2018, a challenge trial was conducted to assess the protective effect of yeast on post-weaning diarrhea in piglets. Pigs were challenged with *E. coli*, a pathogen isolated from a Norwegian pig farm with recurring diarrhea. The trial will tell us how yeast will function under practical farm conditions. This work was carried out in collaboration with industrial partner Norsvin.

3

Genomics and genetics

Today, farmed fish are mainly selected based on growth rate, but fast-growing fish are not necessarily the most feed efficient. In collaboration with industrial partner AquaGen, Foods of Norway has developed new methods for direct selection for improved feed efficiency of salmon under large-scale production systems, based on individual digestibility and the use of stable isotope profiling.

Feed cost is by far the largest cost in the aquaculture industry and by improving feed efficiency by just one percent, value creation can reach 23 million euros per year in Norway alone. Results will be presented in a Ph.D. defence before the summer of 2019.



Photo: AquaGen.

Woody feed one step closer to the market

This autumn, the development of novel, Norwegian feed ingredients has been brought one step closer to commercialization. – We now need to move from academia to industry, says professor Vincent Eijsink in Foods of Norway.



Borregaard operates one of the world's most advanced biorefineries in Sarpsborg.

Foods of Norway is developing novel, protein-rich feed ingredients based on Norwegian biomass such as spruce trees, macroalgae and agricultural co-products. These renewable biomasses are used in the fermentation of yeast – a microbial feed resource. The aim is to reduce Norway's dependency on imported feed ingredients like soy beans and fish meal.

Until recently, the fermentation process has been performed in small bioreactors with a capacity of up to 30 liters at NMBU's biorefinery laboratory.

This September, the fermentation process was scaled up to 200 liters using facilities at Borregaard in Sarpsborg - an important industrial partner in Foods of Norway.

–It is crucial for us to test upscaling as early as possible during process development, because we want to avoid developing processes that are not industrially viable, says professor Vincent Eijsink at NMBU, who is in charge of Foods of Norway's research on novel bioprocessing technologies.

World-class biorefinery

Preliminary results from the initial small-scale trials show that it is possible to produce yeast using Norwegian biomass, and that this yeast can be used as a beneficial protein source in feed for farm animals like pigs and chickens, as well as salmon. However, large-scale trials are needed to confirm that production of yeast can also be successful on a commercial level.

Borregaard operates one of the world's most advanced biorefineries. The company uses pre-treated lignocellulosic biomass to produce the sugar that is used to feed the yeast.

– To us the upscaling is interesting because we want to find out if yeast production can be achieved in a more cost-efficient way, says technology director at Borregaard, Gudbrand Rødsrud.



We have now reached the point where we need to move from academia to industry. Our collaboration with Borregaard allows us to do so.

Professor Vincent Eijnsink, Foods of Norway.

The unbeatable price of soy

To convert trees into sugar, Borregaard needs a certain cocktail of enzymes that does not come cheap. To get the most out of these expensive but indispensable catalysts, Borregaard has collaborated with NMBU over several years.

– Our collaboration with NMBU gives us access to cutting-edge knowledge that improves the use of these enzymes. This helps us lower production costs and increase yields, says Oskar Bengtsson, Section Manager in Borregaard's Business Development R&D.

Although Borregaard's calculations prove that the production of yeast is profitable, it is not yet profitable enough for Borregaard to consider this as a new business area. The low prices of soy protein in the feed industry are a significant barrier to market entry.

– But this might change if we, together with Foods of Norway, can demonstrate additional health benefits for the animals and find ways to reduce the production cost of yeast, Rødsrud adds.



Can chicken make yeast more competitive?

To grow, yeast needs not only sugar, but also nitrogen, vitamins and minerals. Finding the most efficient combination of growth media is thus an important component of the fermentation trials. While ammonia has been used as a nitrogen source in previous trials, chicken by-products are being added in the current production upscaling.

Chicken by-products are processed at industrial scale in the new Bioco plant at Hærland, which involves Foods of Norway partners Nortura, Felleskjøpet Agri and Norilia.

– The bioprocessing facilities at Bioco and the large-scale fermentation facilities at Borregaard are of key importance for Foods of Norway, since they allow upscaling and the production of larger amounts of products to be used in further application testing, such as feed trials, concludes professor Eijnsink.

Joining forces to increase food security



ANA CRUZ

Industrial PhD in Foods of Norway, employed by partner Felleskjøpet Fôrutvikling (2016 - 2019).

The working title of Cruz` thesis is "Novel protein sources produced from advanced bioprocessing for monogastric animals".

Photo: Petter Nyeng.

With one foot in industry and the other in academia, PhD student Ana Cruz is taking our insights into yeast as an animal feedstuff one step forward.

– It's exciting to work with the feed industry while contributing to further our knowledge in animal nutrition. Doing research for Foods of Norway on sustainable feed that might become available on the market in the future really motivates me, says Ana Cruz.

Cruz joined the Centre in 2016 with a Master's degree in Veterinary Medicine from Portugal. Her PhD is a part of the Research Council of Norway's industrial PhD programme.

– The whole idea behind the Foods of Norway project is to produce science that is applied and can be used as a basis for innovation. The industrial Ph.D scholarship is therefore a perfect option for any partner in a centre like Foods of Norway, says Knut Røflo, Managing Director of FKF.

Happy pigs and chickens on a yeast diet?

Foods of Norway aims to reduce Norway's reliance on imported feedstuffs like soy protein and to increase value creation in the aquaculture and agriculture industries.

An industrial PhD ensures a close collaboration between academia and industry and enables Foods of Norway to be responsive to new research ideas and inventions.

– It also facilitates knowledge transfer to industry and the commercialization of our inventions, says Foods of Norway director, Professor Margareth Øverland.

Cruz is doing research on yeast, one of the novel, sustainable feed ingredients developed by Foods of Norway from natural bioresources like wood, seaweed and animal co-products. Today, limited knowledge exists about the use of yeast as a protein source in diets for piglets and chickens with regard to growth performance and health.

– We need more knowledge on how yeast as a protein source will affect feed intake, growth rate and feed efficiency of monogastric animals. We also need to determine how yeast affects nutrient digestibility, gut function, health and welfare of the animals, explains Øverland.

Cruz` main objective is to reduce this knowledge gap by finding out if monogastric animals can grow and thrive on a yeast diet.

– My project will bring us one step forward, the PhD-student says.

Joining forces to increase food security

Since March 2017, Cruz has conducted trials with piglets and chickens in collaboration with NMBU and the University of Copenhagen. In these trials, she replaced protein from traditional ingredients, such as soybean meal, with microbial protein from yeast derived from Norwegian spruce trees.

– I am learning a lot from the multidisciplinary research team in Foods of Norway. My colleagues are working within a wide variety of research fields, such as fermentation, nutrition, health, genetics etc. Maintaining an open communication line between industry and academia is also valuable for the final outcome of our research, she says.

According to FKF, collaborating with academia allows the company to respond more accurately to market needs.

– Being research-based is not enough. For us, science must be practical and contribute to solving actual problems or provide knowledge that supports new developments. Therefore, applying for an industrial scholarship was an obvious path for us to take, says FKF`s director Røflo.



Knut Røflo, Managing Director of Felleskjøpet Førutvikling.



Sheep + seaweed = food security

Farm animals eating seaweed might be the future, but will the meat taste any different? Foods of Norway is about to find out.



For one month during autumn 2018, 24 lambs at Ås farm had part of their traditional diet replaced with sugar kelp, a common type of brown seaweed found along the Norwegian coast. On October 13 people were invited to be guinea pigs, by tasting meatballs from our seaweed trials and filling out a questionnaire at SmakÅs – a food and technology festival in Ås.

– We are looking forward to hear their opinions. What do they think about the taste of the meat and do they approve of the general idea of feeding our farm animals with seaweed? said Per Berg, director of R&D and innovation in Nortura, an agricultural cooperative and industrial partner in Foods of Norway.

Adapting to climate change

The seaweed-fed lambs are a part of Foods of Norway's research on novel feed ingredients from renewable, Norwegian bioresources. Recent studies from the centre confirm that seaweed, when pretreated by means of novel biotechnology, can serve as a protein source for salmon and monogastric animals like pigs.

The lambs, however, were given natural seaweed, dried and chopped but without any bioprocessing. The idea is to see if seaweed can replace some of the roughage in the diets of ruminants. Why?

Last summer's drought made it evident that Norway's self-sufficiency in meat and milk is heavily





Although seaweeds have a long history of use in livestock feed, there is still limited knowledge about their nutritive value and their health effects on animals.

Liv Torunn Mydland, researcher in Foods of Norway



Photo: SINTEF Ocean.

dependent on thriving grass crops. But the grass is a vulnerable feed resource in times of climate change.

To improve food security, we need to search for new, sustainable ways to feed our cattle, sheep and other ruminants. The ocean might be a good place to look.

Unexploited coastline

Norway is blessed with 101,000 kilometers of coastline. This coastline is home to almost 500 species of macroalgae – one of our largest unexploited biomass resources that do not compete directly with human food.

– Although seaweeds have a long history of use in livestock feed, there is still limited knowledge about their nutritive value and their health effect on animals,” says Liv Torunn Mydland, who is in charge of Foods of Norway’s research on the impact of the novel feed ingredients on nutritional value and feed efficiency.

Foods of Norway researchers, in collaboration with Nortura, will now conduct scientific studies on how the seaweed affects the taste of the meat and the animals’ growth.

– This abundant resource has the potential to contribute to the protein and energy requirements of livestock, as well as to improve the health, product quality and sustainability of meat and milk production, says Mydland.

RECRUITMENT

During 2018, Foods of Norway increased its staff with several new researchers, PhD students and a new Communications Advisor.



Fanny Buffetto

Post-doc

Bioprocessing and valorization of brewers' spent grain.



Gergely Kosa

Post-doc

Bioprocessing and fermentation processes.



Gunn Evy Auestad

Communications Advisor

Digital communication and dissemination.



Hanne Fjerdingsby Olsen

Post-doc tenure track

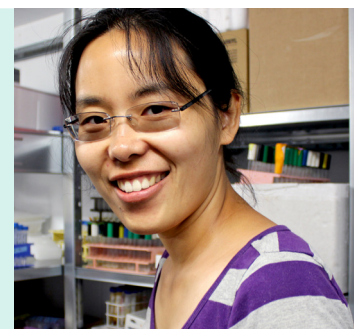
Life cycle assessment (LCA).



Martine Olsen

PhD-student

Influence of novel feeds on milk quality.



Peng Lei

Researcher

In vitro screening of feed components for health effects.



Selina Seyoum Hellestveit

PhD-student

Health and disease resistance in weaner pigs.



Stine Vhile

Assoc. professor

Ruminant nutrition and health.

COMMUNICATION & DISSEMINATION

We have succeeded in establishing knowledge about Foods of Norway among our target groups. In 2018, strategic measures were taken to shift the focus from raising awareness about the centre, to storytelling about key activities and popular scientific dissemination of results.

Starting from last year, communication has also been given a higher priority by employing a Communications Advisor in a 40 percent position.

Foods of Norway's communication is customized towards its **target groups**: decision makers, farmers associations and the general public in Norway, the feed and food industry and the agriculture and aquaculture industries in Norway and abroad.

The Centre management group is weekly being contacted by industrial stakeholders, government-representatives, politicians and/or editorial media both in Norway and abroad. To reach our target groups, we use a diversity of channels: web page, social media (Facebook and Twitter), editorial media, newsletters and participation in both domestic and international seminars and conferences.



Foods of Norway's research was one of the topics on "Nytt på Nytt", one of the most popular comedy shows on Norwegian TV, on November 2, 2018.



Norsk laks er et sårbart industrieventyr - helt avhengig av importert fôr. FOTO: SHUTTERSTOCK/NTB SCANPIX

Oppdrettsnæringens hodepine kan bli et nytt, norsk industrieventyr.

Spiser du laks? Vet du hva den er laget av?



Kommentar
Joachim Lund

NATIONEN

K

gjennomsnittlig bil. Det betyr at importert soya tilsvarende 732.000 biler går til for i Norge hvert år. Da er det ikke likegyldig hvor soyaen kommer fra.

En redselsfull historie

Det aller meste av soyaen som ender i norske dyr og fisk, kommer fra området Mato Grosso i Brasil. Bare soyaen som går til Norge krever et areal på størrelse med

det synlig hvor sårbart det norske mat-systemet er. Norge er helt avhengig av import. Det må utvikles lokale fôrressurser.

Med den kunnskapen i bakhodet kan politikerne bak gardinene heller stille seg følgende spørsmål: Hvordan kan vi redusere soyaforbruket i Norge?

Fisk er verstingen

En urovekkende detalj ved soyaforbruket er at hele 80 prosent av importen går til fisk. De resterende 20 prosentene er fordelt mellom storfe, sau, svin og kylling. Fiskefôret inneholder også den høyeste andelen soya.

Skiftende regjeringer har hatt vekstambisjoner for oppdrettsnæringen. Senest i daværende fiskeriminister Per Espen Stoknes (Frp) at en femdobling av verdien i næringen innen 2050 nok er realistisk. En femdobling av soyaimporten er en katastrofe.

Men det er ikke nok å si at bransjen skal lykkes. Det er å skape arbeidsplasser og sikre de beste. Men de fire

fullt mulig å redusere importen, både på kort og lang sikt.

Vi har mye av mangt her i Norge. Trær, for eksempel. Eller tang og tare. Eller gress. Ved Norges miljø- og biovitenskapelige universitet (NMBU) på Ås er det blitt utviklet enzymer som kan bryte ned trevirke til cellulose og videre til sukker. Ved å dyrke gjør på det kan det bli en fullverdig proteinkilde, faktisk bedre enn soya, ifølge Margareth Øverland, professor ved fakultet for biovitenskap. En livnende prosess kan brukes på tare.

De kortsiktige tiltakene handler om å utnytte eksisterende fôrressurser som raps, bønner, erter og gress. Der er det allerede teknologi som kan øke verdien. Men for å kunne erstatte soya til fordel for andre kilder kreves det politisk vilje og med.

Kapittel

For

Granlaks er en enorm fristelse

Hvis det viser seg å være gjennomførbart i stor skala å erstatte soya med proteiner fra granflis i norsk oppdrettsnæring, er det noe så sjeldent som et forslag som kan gjøre alle til lags.



Foto: Jan-Morten Bjørnbakk / NTB scanpix



NESE FOR TØMMER: Disse norske forskergrisene er foret med norsk tømmer. Grisene har selvfølgelig fått navnet Woody. Forskningsstipendiat Ingrid Marie Håkenåsen koser her med en av treffigrisene i fjaset på Ås. Foto: NMBU

Mat

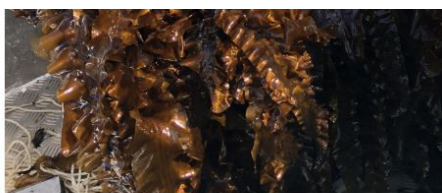
Oppskrifter Matnytt Restauranter Tester

Norsk tømmer og tare blir dyremat:

Snart kan juleribba være laget av griser vokst opp på tømmer

Norske forskere vekker internasjonal oppsikt.

30. OKTOBER 2018 KL. 8:09



- Kanskje har forfedrene våre merket både på seg selv og dyra at tang og tare ikke bare var sikringskost, men også en viktig del av dietten. Dokumentert, skriver forskerne. (Foto: Sintef Ocean)

Havets regnskog er et glemt fôrkammer

FORSKEREN FORTELLER: Helt siden antikken er tang og tare blitt brukt som krisemat og næringstilskudd for folk og fe. Nå kan disse havalgene bli viktige proteinkilder i dyrefôr. Det kan styrke den globale matsikkerheten.

Margareth Øverland
PROFESSOR OG SENTERLEDER, FOODS OF NORWAY,
INSTITUTT FOR HUSDYR- OG AKVAKULTURVITENSKAP,
NMBU

Liv Torunn Mydland
FORSKER, INSTITUTT FOR HUSDYR- OG
AKVAKULTURVITENSKAP, NMBU

Anders Skrede
PROFESSOR EMERITUS, INSTITUTT FOR HUSDYR- OG
AKVAKULTURVITENSKAP, NMBU

IN NUMBERS: COMMUNICATION OUTPUT IN 2018

+ 49 %

We increased the number of Facebook-followers by 49 per cent.

The Explorer

We were launched as profile no. 100 in

The Explorer
– a digital showroom for Norwegian green solutions.

+ 183 %

We were mentioned in 34 articles in editorial media – almost triple the equivalent number in 2017.



Articles in editorial media	Norwegian	30
	International	4
Newsletter*	Number	2
	Followers	110
Facebook	Followers	668
	Avg reach	933
	Avg engagement (post clicks / reactions, comments & shares)	173 / 103
Twitter	Followers	374
	Impressions	45 623

* Created in June 2018, in accordance with GDPR.

PUBLICATIONS

- Chen, C., de Nanclares, M. P., Kurtz, J. F., Trudeau, M. P., Wang, L., Yao, D., Saqui-Salces, M.; Urriola, P.E., Mydland, L. T., Shurson, G.C. Øverland, M. **Identification of redox imbalance as a prominent metabolic response elicited by rapeseed feeding in swine metabolome.** *Journal of Animal Science* 2018; Volume 96 (5), pp. 1757-1768.
- Kidane, A., Øverland, M., Mydland, L. T., Prestløkken, E. **Interaction between feed use efficiency and level of dietary crude protein on enteric methane emission and apparent nitrogen use efficiency with Norwegian Red dairy cows.** *Journal of Animal Science* 2018; Volume 96 (9), pp. 3967-3982.
- Lapena Gomez, D., Vuoristo, K., Kòsa, G., Horn, S. J., Eijsink, V. **Comparative assessment of enzymatic hydrolysis for valorization of different protein-rich industrial byproducts.** *Journal of Agricultural and Food Sciences* 2018; Volume 66, pp. 9738-9749.
- Mosberian Tanha, P., Landsverk, T., Press, C. M., Mydland, L. T., Schrama, J. W., Øverland, M. **Granulomatous enteritis in rainbow trout (*Oncorhynchus mykiss*) associated with soya bean meal regardless of water dissolved oxygen level.** *Journal of Fish Diseases* 2018; Volume 41 (2), pp. 269-280.
- Mosberian Tanha, P., Schrama, J. W., Landsverk, T., Mydland, L. T., Øverland, M. **The effect of plant-based diet and suboptimal environmental conditions on digestive function and diet-induced enteropathy in rainbow trout (*Oncorhynchus mykiss*).** *Aquaculture Nutrition* 2018; Volume 24 (1), pp.112-122.
- Nirea, K. G., de Nanclares, M. P., Skugor, A., Afseth, N. K., Meuwissen, T., Hansen, J. Ø., Mydland, L. T., Øverland, M. **Assessment of fecal near-infrared spectroscopy to predict feces chemical composition and apparent total-tract digestibility of nutrients in pigs.** *Journal of Animal Science* 2018; Volume 96 (7), pp. 2826-2837.
- de Nanclares, M. P., Marcussen, C., Tauson, A. H., Hansen, J Ø., Kjos, N P., Mydland, L. T., Bach Knudsen, K. E., Øverland, M. **Increasing levels of rapeseed expeller meal in diets for pigs: effects on protein and energy metabolism.** *Animal* 2018; Volume 13 (2), pp. 273-282.
- Sharma, S., Hansen, L. D., Hansen, J. Ø., Mydland, L. T., Horn, S. J., Øverland, M., Eijsink, V., Vuoristo, K. **Microbial protein produced from brown seaweed and spruce wood as a feed ingredient.** *Journal of Agricultural and Food Chemistry* 2018; Volume 66 (31), pp. 8328-8335.
- Sharma, S., Neves, L., Funderud, J., Mydland, L. T., Øverland, M., Horn, S. J. **Seasonal and depth variations in the chemical composition of cultivated *Saccharina latissima*.** *Algal Research* 2018; Volume 32, pp. 107-112.
- Øverland, M., Mydland, L. T., Skrede, A. **Marine macroalgae as sources of protein and bioactive compounds in feed for monogastric animals.** *Journal of the Science of Food and Agriculture* 2019; Volume 99, pp. 13-24.

Foods of Norway – 237841/O30

List of personnel 2018

Key researchers	
Name	Main research area
Margareth Øverland	Centre Director; feed ingredient evaluation
Vincent Eijsink	Fundamental and applied enzymology; bioprocessing; management
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
Gro Steine	Economics and sustainability
Anne-Helene Tauson	Monogastric nutrition, physiology and metabolism

Permanent researchers		
Name	M/F	Topic
Svein Jarle Horn	M	Bioprocessing, applied enzymology, management
Björg Egelandsdal	F	Product quality of meat
Bjørge Westereng	M	Biorefining facilities, bioprocesses, analytics
Randi Sørby	F	Veterinary pathology
Nils Petter Kjos	M	Pig nutrition
Stine Vhile	F	Ruminant nutrition and health
Hanne Fjerdingsby Olsen	F	Life cycle assessment (LCA)

Postdoctoral researchers with financial support from the centre budget		
Name	M/F	Topic
Magnus Arntzen	M	Analytics; characterization of biomass and process fractions
Kiira Vuoristo	F	Biorefining, fermentation technology, enzymology
Jon Øvrum Hansen	M	Bioprocessing
Leidy Lagos	F	Pig nutrition, health
Alexander Kashulin-Bekkelund	M	Microbiology
Fanny Buffetto	F	Bioprocessing and valorization of brewers' spent grain
Vladana Grabez	F	Meat quality, proteomics
Caroline Åkesson	F	Veterinary pathology
Alex Crawford	M	Zebrafish screening.
Davide Porcellato	M	Milk mikrobiota

Postdoctoral researchers working on projects in the centre with financial support from other sources			
Name	M/F	Funding	Topic
Adrijana Skugor	F	NFR/EU	Nutrigenomics
Brankica Djordjevic	F	NFR	Fish nutrition and health
Peng Lei	F	NFR	In vitro screening of feed components for health effects
Christian Sahlmann	M	NFR	Macroalgae ecology and food safety
Felipe Revco-Orzua	M	NFR/ external	Animal health, product quality

Monica Suarez Korsnes	F	NFR	In vitro screening of feed components for health effects
Alemayehu Sagaye	M	NFR	Upgrading nutritional value of grass and macroalgae
Gergely Kosa	M	NFR	Bioprocessing and fermentation processes
Jørgen Ødegaard	M	NMBU	Genomics of feed efficiency

PhD students with financial support from the centre budget

Name	M/F	Topic
David Lapeña Gomez	M	Bioprocessing, enzymatic processes, analysis and testing of hydrolysates
Hanne Dvergedal	F	Feed efficiency in fish
Mette Hofossæter	F	Animal health
Stanislav Iakhno	M	Gut microbiota
Selina Seyoum Hellestveit	F	Health and disease resistance in weaner pigs
Martine 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
Sandeep Sharma	M	NMBU	Biorefinery processing
Ana Rita Girio da Costa Cruz	F	Felles- kjøpet/ NFR	Nutrition, novel protein sources produced and monogastric animals.
Ingrid Marie Håkenåsen	F	NFR	Nutrition, novel protein sources, nutrition effect on performance, gut function and health.
Håkon Kaspersen	M	JJA project	Quinolone resistance in E. coli in the gut microbiota
Pabhoda Weththasinghe	F	NFR/No rdic CoE	Growth performance and health in salmon

Master degrees

Name	M/F	Topic
Ida Steine Oma	F	Isolation and characterization of bioactive components in macroalgae

PhD degrees

Name	M/F	Topic
Sandeep Sharma	M	Production of microbial protein from brown seaweed and spruce wood and its use as a novel feed ingredient in aquaculture

Visiting researchers

Name	Period	M/F	Affiliation	Topic
Cristina Tomás Almenar	31.08.18- 30.11.18	F	Inst. Techn. Agrario de Castilla y León	Health beneficial effects of novel feeds
Byron Maximiliano Morales Lange (PhD student)	07.08.18- 02.10.18	M	Catholic University of Valparaíso	Mucosal immunity

Ewelina Koziol (PhD student)	20.03.18- 15.05.18	F	Medical University of Lublin	Zebrafish <i>in vivo</i> models
Adrianna Skiba (PhD student)	20.03.18- 31.05.18	F	Medical University of Lublin	Zebrafish <i>in vivo</i> models
Hin Fai Kwok	10.06.18 – 14.07.18	M	Chinese University of Hong Kong	Laser microdissection
Narges Shahbazi (MSc student)	29.10.18- 29.04.19	F	Royan Institute of Stem Cell Biology, Tehran	Zebrafish <i>in vivo</i> models
Elena Coll (PhD student)	07.12.18- 16.12.18	F	Inst. of Agrifood Research & Technology, Spain	Fatty acids in lamb
Monica Imarai	27.11.18- 29.11.18	F	University of Santiago	Immunological markers and functional diets
Valentina Wong Benito	07.05.18- 04.07.18	F	University of Santiago	Isolation and characterization of immune cells of distal intestine of salmon

Statement of accounts

Foods of Norway costs 2018 (1000 NOK)

Host NMBU	Industry partners (Norway)	International partners	Equipment	Total costs
24 212	6 086	684	0	30 982

Foods of Norway funding 2018 (1000 NOK)

Host NMBU	Industry partners (Norway)	International partners	Research Council	Total funding
9 281	7 939	354	13 408	30 982



FOODS^{OF}NORWAY

Annual report 2018

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