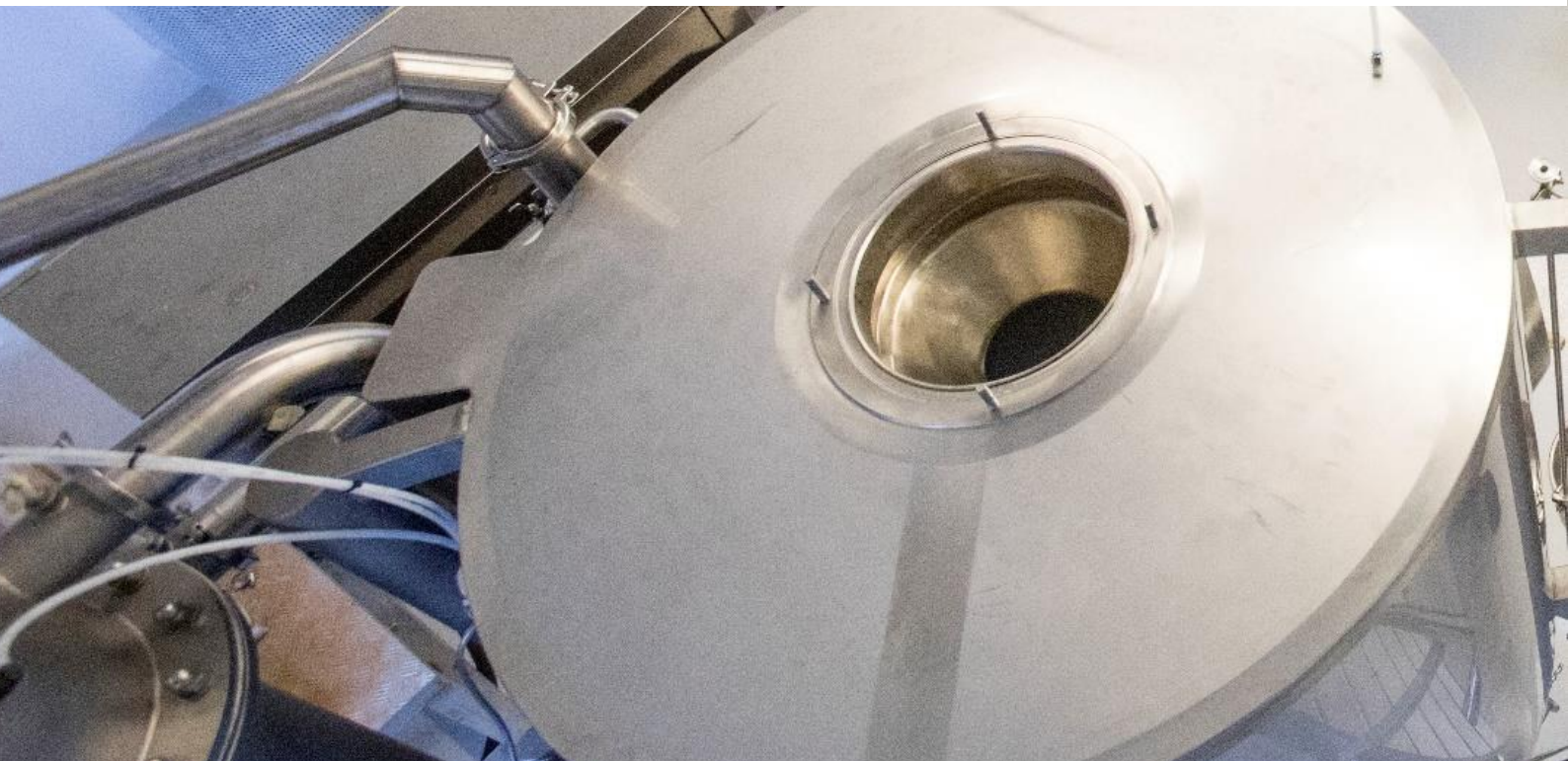


FOODS OF NORWAY

Annual Report 2017



Contents

Centre for Research-based Innovation
The Research Council of Norway

The Research Council of Norway

Norwegian University of Life Sciences

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

Summary of the year 2017

Foods of Norway focuses on research and innovation to develop novel feed ingredients from natural bioresources, and on improving feed utilization through industrial exploitation of cutting-edge research on processing and (bio)technology, nutrition, health, genetics and food quality.
This summary will take you through the highlights of 2017.

Research
Our work on the development of novel feeds and processing technology has concentrated on developing methods for hydrolysis of protein-rich animal co-products and seaweed to be used as nutrient sources in fermentation media to produce yeast. In parallel, we have evaluated the most suitable yeast strains for the fermentation media. This includes extensive growth testing of various yeast strains in lab-scale fermentations. In collaboration with the NorZymeD project, we have been developing novel enzymes for seaweed processing.

In 2017, we succeeded in completing the first phases of upscaling the fermentation of yeast. We have conducted several 30-litre fermentations in the Norwegian University of Life Sciences (NMBU) biorefinery laboratory, which has allowed us to produce enough yeast from spruce trees and seaweed hydrolysates for a growth performance experiment with salmon. This is an important milestone in Foods of Norway, and one of great scientific, industrial, and also symbolic, significance.

The first study with yeast in diets for piglets was performed. Three different experimental diets were designed, with increasing levels of yeast, replacing 10, 20 and 40 percent of the protein from conventional protein-rich feed ingredients. Feed intake and growth rate of the piglets were measured. Ileal and total tract nutrient digestibility was determined, and a range of health parameters was measured.

Cooperation between partners
Foods of Norway is a large research centre with many partners. Continuous efforts are made to include all the partners in planning activities, discussing results and mapping out the way forward. Inputs from our industry partners on what research to prioritize is also valuable. Two joint meetings with all the partners were held in 2017, in addition to two workshops and several smaller meetings.

Visibility
Foods of Norway emphasizes the importance of communication and dissemination of information. In the course of 2017, some 30 presentations on the centre's activities and research findings were given at seminar's and meetings. The centre has been visible in the media through profiles and interviews in newspapers, trade journals and magazines, TV and radio.

Vision and objectives

The vision of Foods of Norway 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 in 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:
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 cattle) for optimal production economy and minimal environmental impact.

Provide knowledge to ensure that the use of novel feed ingredients supports 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.

Photo: Torstein Garmo

Research plan

Background

Today, the Norwegian fish farming and farm animal industries rely largely on imported plant ingredients, such as soybeans. In addition, the use of human food as feed ingredients has been questioned, both for ethical and economic reasons. Future fish and animal production will require competitive and sustainable novel feed ingredients produced from non-food resources. Existing feed resources need to be used 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 resources, but possesses large natural bioresources such as trees, grass, macroalgae, and co-products from fish, animals and plants that can provide a basis for the production of novel feed ingredients.

Foods of Norway has a special focus on developing 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 centre thus aims to develop new, innovative processing techniques by exploiting state-of-the-art biorefining technologies that allow conversion of natural bioresources into high-quality feed ingredients for fish and farm animals.

The plan

The research plan of the centre includes six integrated work packages, each of which comprises several sub-tasks. 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.

Wood consists of three main constituents: cellulose, hemicellulose and lignin. In the biorefinery process, lignin will be separated out and used for high-value products, while cellulose and hemicellulose will be converted into sugars and used in the fermentation of certain yeast strains for the production of single-cell proteins.

We also aim to develop feed ingredients and high-value functional products based on macroalgae by using novel cultivation and harvesting technologies and new downstream processing methods. A major task will be to upgrade the nutrient value of the seaweed by a biorefinery process so we make use of the entire biomass in the fermentation process for the production of yeast.

Furthermore, Foods of Norway will have a special focus on improving feed efficiency and robustness of fish and farm animals by combining important phenotypic traits, new biomarkers for feed utilization and advanced genomic analysis to support genetic adaptation to existing and novel feed resources. Improvements in feed efficiency allow for the production of more food from feed resource inputs, and reduce feed costs and impact on the environment.

Photo: Shutterstock

Work package	Leader	Main objective
WP1: Development of novel feeds and processing technology	Vincent Eijsink	• Develop novel feed ingredients based on local low-value non-food biomass from forest, coastal areas, and agricultural land, either by directly converting the biomass to a feed ingredient or by converting the biomass into single cell protein. • Upgrade existing feed resources by improved processing technologies. • Improve the nutritional value of grass silage.
WP2: Impact of novel and improved feed ingredients on nutritional value and feed efficiency	Liv Torunn Mydland	• Investigate how diets based on novel and improved feed resources affect growth performance, energy and nutrient utilization in fish, chicken, pigs and dairy cows. • Study metabolic responses to increased levels of novel and improved feed resources e.g., changes in metabolic pathways, microbiota population, mitochondrial function, as well as regulatory metabolic and gastrointestinal hormones in fish, pigs, and broiler chicken. • Study metabolic responses, including rumen fermentation in dairy cattle. • Perform multi-mix optimization of the novel feed resources for optimal resource utilization across species. • Model the biological processes and to include important parameters in the existing NorFor model for dairy cows.
WP3: Impact on fish and animal health	Charles McLean Press	• Study dietary effects on the structure and functions of intestine, composition of microbiota, interactions between the host microbes, and general health in fish, pigs, broiler chicken and dairy cows. • Evaluate whether the beneficial effects of yeast also improve gut health in ruminants. • Evaluate effect of diets based on novel ingredients on disease resistance in fish and pigs; and • Integrate all available information into dynamic and mechanistic gut homeostasis models that will predict nutritional impact on fish and animal health.
WP4: Food quality assessment	Siv Skeie	Evaluate the impact of novel feed resources on the quality of: • Milk and fermented milk products (yoghurt and cheese) • Chicken and pig meat • Cattle meat • Fish products

Work package	Leader	Main objective
WP5: Genomics and genetics of feed efficiency, health and robustness	Gunnar Klemetsdal	• Establish methods (with WP2) for high throughput phenotyping for individual animal digestibility and /or feed intake. • Collect phenotypes and genotypes for individual digestibility and/or feed intake in salmon. • Develop statistical models and study genetic and genomic differences in digestibility in salmon. • Study genomic variations and identify candidate functional mutations (SNPs) that can be used for assess genomic prediction of digestibility. • Study effect of increased digestibility on other important traits. • Combine detailed biological information to identify new selection criteria for implementation in the breeding schemes.
WP6: Economical and environmental impact	Gro Steine	• Assess the value of novel and improved feed resources in relation to the performance of the animal. • Assess the environmental footprint of the novel and improved feed resources by Life-Cycle Analyses (LCA). • Assess the environmental impact of improved FE. • Assess the consumer socio-economic aspects of the food products. • Assess the potential for large-scale production of the ingredients developed and documented in WP 1-4.

Photo: Janne Karin Brodin

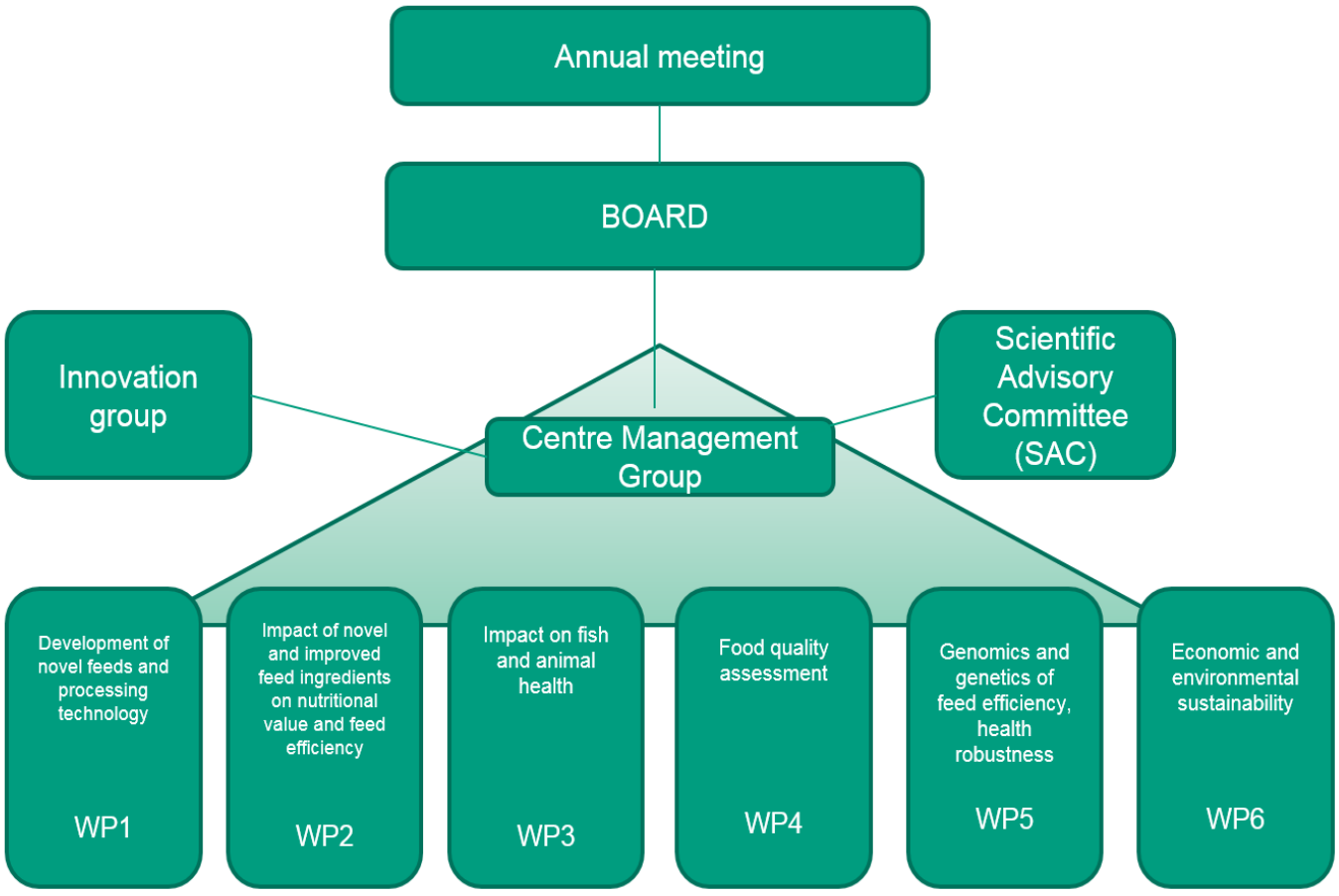
Organization

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, and in particular that the activities presented in the project description are performed within the stipulated budget and time frameworks.

The Centre Director will be 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 Innovation Group will advise specifically on innovation related to centre activities, promote research activities to politicians and other decision makers, and provide advice on how results, ideas and concepts generated in the centre could potentially be commercialized.



The Board (until August 1)

- Knut Røflo (Chair), Felleskjøpet Fôrutvikling
- Torstein Steine (Deputy Chair), NMBU/ Faculty of Biosciences, Department of Animal and Aquacultural Sciences
- Nina Santi, AquaGen
- Gudbrand Rødsrud, Borregaard
- Morten Sollerud, Norilia
- Eirik Selmer-Olsen, TINE
- Ragnhild Solheim, NMBU/ Research and Innovation Department
- Anne Storset, NMBU/ Faculty of Veterinary Medicine

Board until August 1. From left: Torstein Steine, Ragnhild Solheim, Nina Santi, Knut Røflo, Anne Storset, Gudbrand Rødsrud, Morten Sollerud. Eirik Selmer-Olsen, was not present.

Photo: Håkon Sparre

The Board

- Knut Røflo (Chair), Felleskjøpet Fôrutvikling
- Ragnhild Solheim (Deputy Chair), NMBU/ Research and Innovation Department
- Nina Santi, AquaGen
- Gudbrand Rødsrud, Borregaard
- Morten Sollerud, Norilia
- Eirik Selmer-Olsen, TINE
- Kari Kolstad, NMBU/ Faculty of Biosciences
- Ågot Aakra, NMBU/ Faculty of Chemistry, Biotechnology and Food Science

New board members:

Ågot Aakra

Kari Kolstad

Centre Management Group

- Margareth Øverland, Centre Director [1)]
- Vincent Eijsink, WP1 leader [2)]
- Liv Torunn Mydland, WP2 leader [1)]
- Charles McLean Press, WP3 leader [3)]
- Siv Skeie, WP4 leader [2)]
- Gunnar Klemetsdal, WP5 leader [1)]
- Gro Steine, WP 6 leader [1)]

[1)] NMBU/ Faculty of Biosciences, Department of Animal and Aquacultural Sciences
[2)] NMBU/ Faculty of Chemistry, Biotechnology and Food Science
[3)] NMBU/ Faculty of Veterinary Medicine, Department of Basic Sciences and Aquatic Medicine

From left: Charles McLean Press, Margareth Øverland, Siv Skeie, Gunnar Klemetsdal, Gro Steine, Vincent Eijsink, Barbara Eriksen, Liv Torunn Mydland.

Photo: Janne Karin Brodin

Partners with broad multidisciplinary expertise

The Foods of Norway consortium comprises four departments at NMBU, one international academic partner and four associated international academic partners, and 18 partners in industry and innovation, representing forestry, aquaculture and agriculture.

Academic partners:
NMBU:

- Faculty of Biosciences (host)
- Faculty of Chemistry, Biotechnology and Food Science
- Faculty of Veterinary Medicine

International:

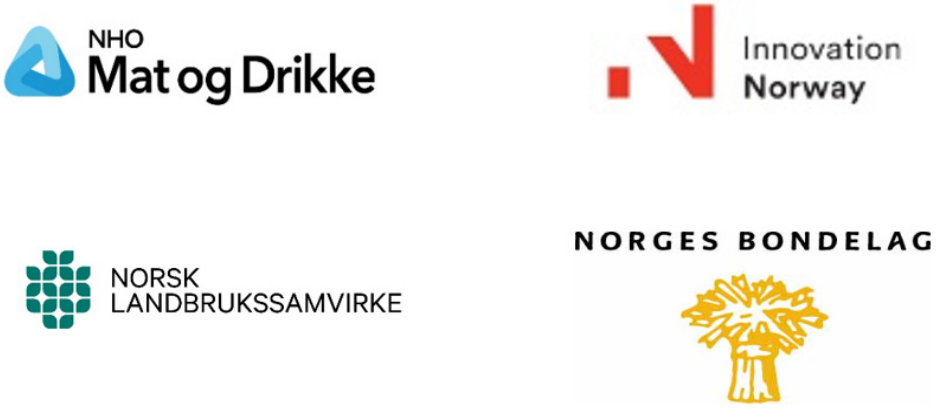
- University of Copenhagen (partner)
- Aarhus University
- University of Minnesota
- University of Western Australia
- US Department of Agriculture – ARS

Industry:

- Agrifirm Innovation Centre
- Animalia
- AquaGen
- Borregaard
- Felleskjøpet Fôrutvikling
- Geno
- Norilia
- Norske Felleskjøp
- Norsvin
- Nortura
- Seaweed Energy Solutions
- The Norwegian Farmers' Union
- TINE
- Viken Skog
- Yara

Supporting partners:

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



Centre activities in 2017

Cooperation between partners

Two joint meetings with all partners in Foods of Norway were arranged during 2017. The first meeting was held on 3-4 May. The meeting provided an arena for partners and researchers to meet and discuss activities and expectations, both within and across work packages. At the partner meeting, research highlights were presented and discussed. A workshop on the definition and registration of innovation was also conducted during the meeting. The Scientific Advisory Board (SAC) was also present. At the end of the meeting, SAC presented their views of the centre's activities and after the meeting, they delivered an evaluation report. The annual meeting followed the partner meeting on 4 May.
The second meeting was a workshop 20 October, where annual plans and milestones for 2017 were discussed.

Photo: NMBU

During 2017, we arranged two major workshops. In June, we invited the industry partners to a workshop to discuss what kind of software to use in Life Cycle Assessment (LCA) estimations.

During 2017 particular emphasis was placed on developing yeast at NMBU's biorefinery laboratory based on Norwegian biomass from land and sea. The second workshop was a strategic discussion of yeast production with all the partners in Foods of Norway in October. There have also been follow-up meetings in planning activities and implementation in other work packages.

Extensive work on assessing the effect of yeast as a novel feed ingredient in diets for pigs on performance and health has been performed. These experiments are performed in close collaboration with many of the industrial partners and they have been conducted in close collaboration between several work packages. Two experiments have been performed; the first experiment evaluated the effect of yeast on growth performance, nutrient digestibility and health during the first period after weaning, and the second experiment evaluated the potential carry-over effect of feeding yeast-based diets during the weaning period on subsequent performance and health during the growing-finishing period.

A large experiment to upgrade the nutritional quality of grass silage using novel methods has started. The work is undertaken in close collaboration with several industrial partners including Tine, Yara and AgriFirm.

Extensive work has been performed to develop methods to directly select for improved feed efficiency in Atlantic salmon. During 2017, two experiments with Atlantic salmon were conducted in close collaboration with AquaGen.

Seminar

In April, Foods of Norway, SINTEF Ocean and SIG Seaweed joined forces to hold a joint seminar on seaweed. More than 100 people attended the meeting to learn and exchange knowledge. Foods of Norway and SINTEF Ocean will continue to exchange knowledge on seaweed.

Margareth Øverland, Svein Jarle Horn, Sandeep Sharma, Liv Torunn Mydland

Photo: NMBU

On November 30, Marta Perez de Nanclares Fernandez defended her PhD thesis "Rapeseed co-products in pig diets – Effects on nutrient and energy digestibility and metabolism". The following day opponent Hans H. Stein gave a talk entitled: "Use of feed technology to increase the nutritional value of diets for pigs". The work was done in close collaboration with the FeedMileage project (RCN grant no. 233685/E50).

Scientific activities and results

Research highlights in 2017

The work on development of novel feeds and processing technology has concentrated on developing protocols for hydrolysis of protein-rich products from Norilia and Nutrimar and seaweed from Seaweed Energy Solutions. Simultaneously, we have tested and compared yeast strains in collaboration with SLU. In collaboration with the NorZymeD project, we have been developing novel (and highly necessary) enzymes for seaweed processing. Importantly, we have carried out extensive testing of the growth of various yeast strains in lab-scale fermentations, on growth media based on Norwegian biomass (spruce, seaweed, meat by-products). Part of this work is being conducted in collaboration with the The Research Council of Norway (RCN) project BIOFEED (grant no. 239003/O30).

Inspired by this developmental work, we have managed to go through the first phases of upscaling. For the most interesting and effective combinations of growth media and yeast type, we have now conducted multiple 30-l fermentations in the NMBU biorefinery laboratory, which has allowed us to produce enough yeast biomass from tree and seaweed hydrolysates for a salmon feeding experiment. This is an important milestone in Foods of Norway, which is of great scientific, industrial, and symbolic, importance.

Downstream processing (DSP) of the yeast is important for several reasons. DSP will affect the nutritional quality of the yeast as a feed ingredient, for example by affecting the protein bioavailability. It is imperative to determine the molecular constituents that are responsible for the health beneficial effects in yeast. We will study this as part of our DSP work. For example, by fractionating the cell wall, we may identify health-promoting factors or components, while making yeast protein more accessible. Notably, there are conceivable scenarios where the nutritional value of the yeast can be improved by a process step that liberates valuable compounds from the yeast for use in other applications. Thus, additional value may be created.

This work brings about major analytical and other quite fundamental challenges, but it opens up for innovations (e.g. processing methods, or creation of additional value out of cell wall fractions).

The work on DSP and fractionation of yeast is tightly coupled to the development of an in vitro assay for rapid (and relatively cheap) testing of the functionality of various yeast fractions.
To test diets with yeast we have conducted one feed trial with piglets and we started one feeding trial that lasted until February 2018.

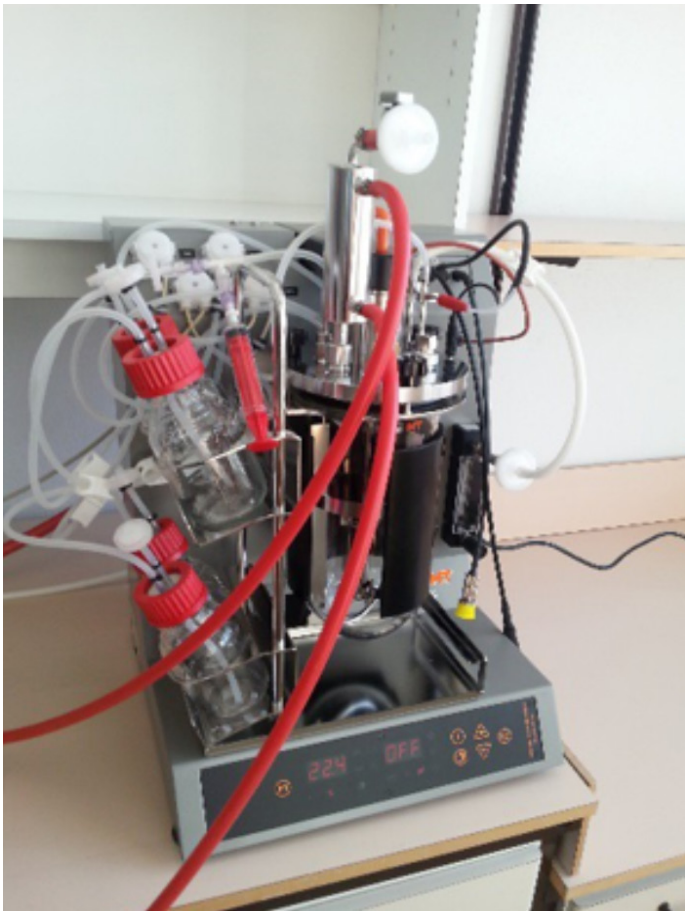


Photo: NMBU

Photo: Hanne Dvergedal

Genomics and genetics of feed efficiency (FE), health and robustness has focused mainly on FE. Different approaches have been developed to study feed efficiency in salmon. In salmon, where individual feed intake (FI) measurements are currently impossible to obtain, biomarkers for individual protein and energy efficiencies are used.

An initial experiment with salmon has been performed to establish methods for measuring new phenotypes in a family material with pre-smoltified fish during 2017. These experiments have been carried out in close collaboration with AquaGen.

Below is more information about the feeding trial with piglets, and activities with grass and gut health.

Can piglets eat trees?

Shortage of proteins is a global challenge for food security. The aim of Foods of Norway is to develop and document the effects of novel feed resources from biomasses such as Norwegian spruce. Yeast grown on sugars from tree biomass has proven to be a high-quality protein source in diets for fish. Previous experiments with salmon have shown positive effects of yeast on both feed intake and growth rate as well as gastro-intestinal health.

First study with yeast for piglets

At the university farm, Ås gård, 48 piglets at 4 weeks of age were fed diets with yeast produced from Norwegian tree biomass. Three different experimental diets were used, with increasing levels of yeast replacing 10, 20 and 40 percent of the protein from protein-rich feed ingredients normally used today. In addition, one control group based on conventional protein sources such as soybean meal, potato protein concentrate, fishmeal, and rapeseed meal was used.

Documented health effects

Parameters that were documented in this experiment included individual feed intake and growth rate, ileal and total tract nutrient digestibility, as well as a range of health parameters.

The gut, in particular, was investigated to see how different levels of yeast affect the gut bacterial communities, and general gastro-intestinal health and function. We know from previous experiments in salmon that yeast contains bioactive components that strengthen the gut barrier function and modulate the immune system.

Photo: Håkon Sparre

Results

The results of this study demonstrate that yeast produced from Norwegian spruce trees can be a high-quality protein source in diets for weanling piglets. The yeast has a high protein content with a nutritionally favorable amino acid composition and with a high digestibility.

We also observed that the pigs liked the yeast; they ate and grew well, and had fewer typical post-weaning problems such as diarrhea, especially during the first week after weaning. We are now in the process of performing a wide range of analyses of the gut tissues, organs and blood to further reveal the mechanisms behind the improvement in growth performance and gut health when feeding yeast to piglets.

Improving the nutritional value of grass silage

The nutritional value of forage is often limited by its high fiber content, and traditional methods have shown to be unfit to improve the digestibility of the forage. Improvement of the nutritional quality of the forage through targeted processing would alter resource utilization and feed efficiency and lower feed costs, which are major goals for Foods of Norway's research.

Groundbreaking research

Together with industry partner TINE and local Norwegian farmers, Foods of Norway has collected grass silage from 100 farms all over Norway. This effort forms the basis for an ongoing large-scale experiment where digestibility of ruminants is measured and more robust methods are applied, based on mechanical, chemical and novel enzymatic pretreatments. This modern technology can even be used to optimize grass of inferior quality due to rain, which is a growing challenge in the face of climate changes.

This is groundbreaking research as such large amounts of silage of different qualities have never been studied in such detail before. The collected silage is also used by TINE in the testing of a "near-infrared spectroscopy" (NIR), an instrument intended to measure grass quality and help the farmer adjust feed rations. This in turn can make farming more cost-efficient and reduce greenhouse gas emission.

Photo: Håkon Sparre

Novel feeds' effect on animal gut health

Foods of Norway aims to feed fish and farm animals using new ingredients produced from trees and macroalgae. These new feeds will affect the composition of the microbiota and the cells of the gut. To help predict the effects of new feed ingredients on the animal's health, our scientists are performing high-resolution studies of individual animals' defense cells, microorganisms and gene expression in the intestine.

The scientists are hunting for markers that may indicate whether a certain feed ingredient has a positive or negative effect on animal health. Different types of feed are tested to measure effects on health to form the basis for a model. The findings will be important for Foods of Norway's aim to increase feed efficiency and robustness of fish and farm animals.

The microbes and different cells of the gut crosstalk by sending signals to each other. Mapping the signals that pass between the cells and microbiota can tell us something about gut health and the effect of novel feeds.

Unique cross-disciplinary approach

The project is unique by combining various research expertise. This cross-disciplinary approach, including both microbiologists and pathologists, allows scientists access to information that otherwise would have been overlooked. Studies of the gut in individual animals will give more relevant and precise data on specific microbes to correlate with host parameters, and to reveal the mechanism of pathogenic species that cause health problems in production animals.

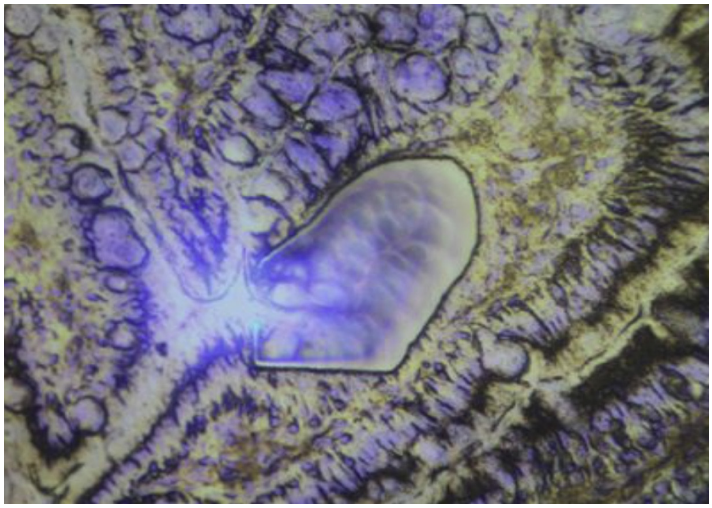


Photo: Liv R. Bjergene

International cooperation

Foods of Norway has two international consortium partners - University of Copenhagen (DK) and Agrifirm Innovation Centre (NL) - in addition to several associated partners (Århus University (DK), University of Minnesota (US), University of Western Australia (AUS), USDA-ARS (US) and the Swedish University of Agri¬cultural Sciences (SLU).

Collaboration with our international partners has been an integral part of planning research activities and experiments to develop feed resources and in the evaluation of these experiments with farm animals.

Foods of Norway has a close collaboration with Lallemand. Lallemand has produced the yeast that has been used in the feeding trials for pigs during 2017.

Sustainability of pig production through improved feed efficiency (SusPig)

The SusPig project is an ERA-NET. The main focus of the project is conversion of feed into animal product (meat) at a minimum cost and without compromising environmental resources. SusPig aims to improve sustainability of European pig production through improved nutritional quality of locally produced feed resources, and development of more efficient and robust animals that can utilize these feed resources. This will be accomplished by combining the expertise of five European research groups in collaboration with USA and Australia through a novel multidisciplinary approach involving pig production, physiology, nutrition, genetics, and system modelling.

Recruitment

During 2017 Foods of Norway has increased its staff by recruiting two PhD students and two Post doc's. One of the PhD students is working with novel protein sources for pigs and the work is linked to the FeedMileage project. The second PhD student works with assessing the effect of novel feed resources on intestinal health. 2017 has been a productive year with many research activities, thus we have also employed two more technicians. During the Centre period, the goal is to recruit at least 20 Master students, 12 PhD students and 6 Post doc's. The gender distribution in the center is about fifty percent female and male.

New people during 2017

Researchers:

Leidy Lagos is a researcher in nutrition and immunology of monogastric farm animals. She is responsible for assessing the impact of novel feed resources on immune function and health of pigs and fish as well as developing in vitro screening methods to assess health-benefi**c**ial effects of novel feed resources and bioactive components for farm animals.

Caroline Piercy Åkesson is a researcher working with veterinary pathology, histology, immunohistochemistry, laser microdissection and molecular techniques. The research focus is gut health in production animals.

Post docs:

Alexander Kashulin-Bekkelund is a researcher in animal health and microbiology. His research area is mainly on gut microbiota analysis such as metagenomics and metatranscriptomics.

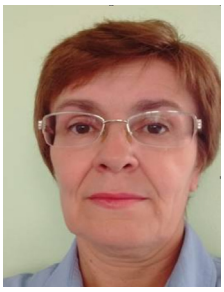
Vladana Grabez is a researcher in muscle and meat biology, and lipid nutrition. Her research area is mainly on the impact of novel feed resources on product quality.

PHD's:

Ingrid Marie Håkenåsen is studying for her doctoral degree where she is evaluating the effect of novel protein sources on growth performance, digestive capacity, gut integrity and function of piglets.

Stanislav Iakhno is studying for his doctoral degree where he is evaluating the effect of novel feed resources on gut microbial community and health.

Technicians:



Milena Bjelanovic is a research technician and has worked with activities related to Foods of Norway since January 2017. She is involved in several of Foods of Norway's work packages. She investigates the nutritional value and potential health benefits of novel feed ingredients in feed to fish and other domestic animals. She also takes part in the planning and sampling of Foods of Norway experiments, as well as regular work in the laboratory.

Ricardo Tavares Benicio is a research technician and has worked with activities related to Foods of Norway since August 2017. He is mainly involved in many activities connected to feed processing, feed manufacture and assessment of novel feed resources in diets for farm animals. Ricardo takes part in the planning, conducting and sampling of Foods of Norway experiments, as well as regular work in the laboratory.

Aleksandra Göksu is a research technician working with histology, immunohistochemistry, laser microdissection and molecular techniques.

Communication and dissemination activities

Communication strategy
The media showed a great interest in Foods of Norway even before the centre officially opened. The interest in the centre has continued.

Foods of Norway emphasizes the following main principles for communication:

- Accessible
- Clear
- Independent

Our target groups for internal and external communication are:

Internal:

- Industry and research partners

External:

- Decision makers
- Public opinion

In order to reach the various target groups, a combination of written, verbal and electronic information has proved successful.

Facebook	Number of followers	473
	Records since opening	73
Newsletters	Number since opening	5
Op-Eds	Number since opening	12
Popular science articles	Norwegian media	12

Foods of Norway's newsletter
Foods of Norway has established a website, www.foodsofnorway.net/ where information about the centre is published. In addition, we use Facebook, www.facebook.com/NMBUFON/, for continuous updates. As part of our communication strategy, we issue an electronic newsletter twice a year to all partners and others in our network. The newsletters are also published on our website: https://www.foodsofnorway.net/news/newsletter

The newsletter features research news highlights, ongoing activities and new members of staff.

Keynote lectures
In the course of 2016, Foods of Norway researchers have given 34 talks at seminars and meetings.

Selected talks:

Alger Biotech
Centre Director Margareth Øverland was invited to give a presentation at the Norwegian Biotechnology Advisory Board innovation week on September 28, 2017 in Oslo. Professor Øverland gave a talk to public decision-makers, private sector leaders and public society leaders on how we can use seaweed as a feed resource. The title of her talk was "Seaweeds as a feed resource – potential and constraints".

Bioeconomy for breakfast
What is bioeconomy and what does it mean for the food we eat? On September 20th the Norwegian Research Council invited all those interested to breakfast with a bioeconomic twist to learn about bioeconomics in practice, accompanied by talks from researchers and experts about what bioeconomy can be. Centre coordinator Dr. Gro Steine gave a talk about Foods of Norway's role in the Bioeconomy. The title of her talk was "Foods of Norway from trees and microalgae to animal feed".

Foods of Norway in the media
Foods of Norway has a proactive media plan. We work strategically towards the media in order to reach our target groups for communication.

Media has shown great interest in Foods of Norway's research. In the beginning of 2017 Foods of Norway participated in two TV features. Centre Director Margareth Øverland participated in a film "Utan mat og drikke" about how a family in Norway can manage by only eating food produced in Norway. In the film, Øverland gives an introduction to how research and new technology is a part of the solution.

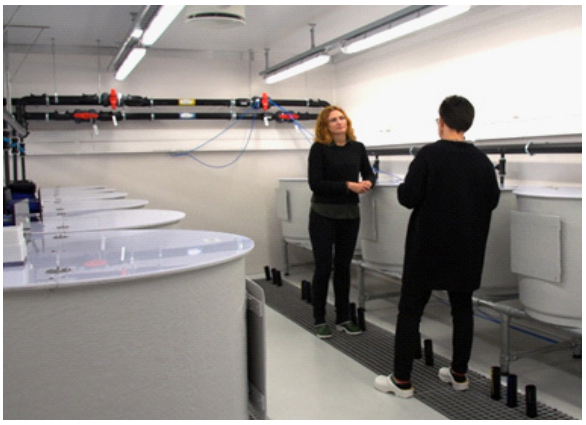


Photo: Vestnorsk filmsenter

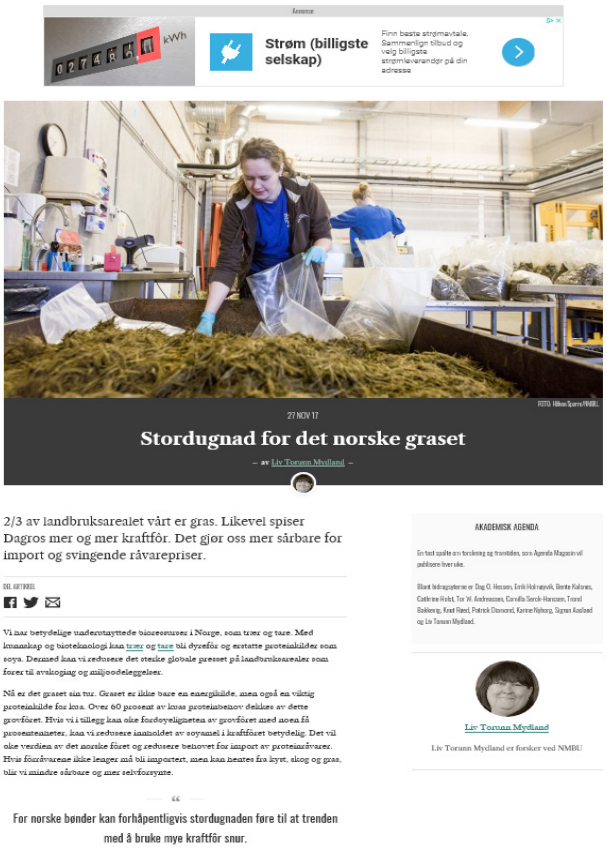
Norway's national broadcasting channel, NRK, presents how Foods of Norway works to find alternative sources of protein by developing sustainable feed ingredients from natural bioresources.
https://tv.nrk.no/serie/distriktsnyheter-oestlandssendingen/DKOA99030717/07-03-2017#t=2m58s

Photo: Janne Karin Brodin

Here are some examples from the Norwegian media:

07.03.2017 NRK

23.02.2017 Dagens Næringsliv



27.11.217 Agenda Magasin

Other activities

Forskningstorget

The theme of this year's Forskningstorget was 'values'. Foods of Norway was present at Forskningstorget in Oslo 22-23 September 2017, demonstrating and explaining to schoolchildren and other visitors how trees and seaweed are converted to feed.

Photo: Gro Steine

Attachment

Personnel

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

Visiting researchers

Name	Period	M/F	Affiliation	Topic
Javier Gimpel	26.04.17-24.05.17	M	ICDB, Univ. of Chile	Biorefining of macroalgae
Jessica Couture	30.05.17-02.06.17	F	Univ. California at Santa Barbara	Life Cycle Assessment

Researchers with financial support from the Centre budget

Name	M/F	Topic
Svein Horn (professor)	M	Bioprocessing, applied enzymology, management
Bjørg Egelandsdal (professor)	F	Product quality of meat
Christian Sahlmann	M	Macroalgae ecology and food safety Fish nutrition
Magnus Arntzen	M	Analytics; characterization of biomass and process fractions
Bjørge Westereng	M	Biorefining facilities, bioprocesses, analytics
Kiira Vuoristo	F	Biorefining, fermentation technology, enzymology
Leidy Lagos	F	Pig nutrition, health
Felipe Reveco-Urzua	M	Animal health, product quality
Alexander Kashulin-Bekkelund	M	Microbiology
Vladana Grabez	F	Meat quality, proteomics

Researchers working on projects in the Centre with financial support from other sources

Name	M/F	Funding	Topic
Jon Øvrum Hansen	M	NFR	Bioprocessing
Randi Sørby (assoc. professor)	F	NMBU	Veterinary pathology
Caroline P Åkesson	F	NFR	Veterinary pathology
Hanne Fjerdingby Olsen	F	NMBU/NFR	Life cycle assessment
Jørgen Ødegaard (adjunct assoc. professor)	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

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	Industry PhD. Felleskjøpet/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.
Stanislav Iakhno	M	NMBU	Gut microbiota
Håkon Kaspersen	M	JJA project	Quinolone resistance in E. coli in the gut microbiota

Master degrees

Name	Period	M/F	Topic
Marte Helene Tøfte	15.08.17-15.05.18	F	Feed efficiency in fish
Oluwaseun George Shomorin	01.09.16-20.05.17	M	Testing new feed- and feces collection systems for Atlantic salmon
Ingrid Marie Håkenåsen	14.12.16-09.06.17	F	Feed intake, nutrient digestibility, growth performance and general health of piglets fed increasing levels of yeast
Ida Steine Oma	14.08.2017-15.05.2018	F	Isolation and characterization of bioactive components in macroalgae

Statement of Accounts

Foods of Norway costs 2017 (1000 NOK)

Host NMBU	Industry partners (Norway)	International partners	Equipment	Total costs
20 047	5 914	646	0	26 607

Foods of Norway funding 2017 (1000 NOK)

Host NMBU	Industry partners (Norway)	International partners	Research Council	Total funding
7 039	7 564	421	11 583	26 607

Publications

Kurtz, J. F., Chen, C., de Nanclares, M. P., Trudeau, M., Yao, D., Saqui-Salces, M., Urriola, P. E., Mydland, L. T., Shurson, G. C., Overland, M. **Effects of rapeseed feeding on swine metabolome.** Journal of Animal Science 2017; Volum 95

Pérez de Nanclares, M. ; Trudeau, M.P. ; Hansen, J.Ø. ; Mydland, L.T. ; Urriola, P.E. ; Shurson, G.C. ; Piercey Åkesson, C. ; Kjos, N.P. ; Arntzen, M.Ø. ; Øverland, M. **High-fiber rapeseed co-product diet for Norwegian Landrace pigs: Effect on digestibility.** Livestock Science 2017. Volume 23.

Ravanal, María Cristina, Sharma, Sandeep, Gimpel, Javier, Reveco-Urzua, Felipe E., Øverland, Margareth, Horn, Svein Jarle, Lienqueo, María Elena. **The role of alginate lyases in the enzymatic saccharification of brown macroalgae, Macrocystis pyrifera and Saccharina latissimi.** Algal Research, September 2017, Vol.26, pp.287-293

P. Mosberian-Tanha, J.W. Schrama, T. Landsverk, L.T. Mydland, M. Øverland. **The effect of plant-based diet and suboptimal environmental conditions on digestive function and diet-induced enteropathy in rainbow trout (Oncorhynchus mykiss).** Aquaculture Nutrition/ 10.1111/anu.12539

Master thesis

Håkenåsen, Ingrid Marie
Feed intake, nutrient digestibility, growth performance and general health of piglets fed increasing levels of yeast. Ås: NMBU, IHA 2017.

Shomorin, Oluwaseun George
Evaluating retch wire screen as a new tool for feces collection in digestibility assessment in fish: the impact of nutrient leaching on apparent digestibility of fishmeal, soybean meal and rapeseed meal diets in rainbow trout (Oncorhynchus mykiss). Ås: NMBU, IHA 2017

Photo: Gisle Bjørneby

Photo: Håkon Sparre

Host institution

Norwegian University of Life Sciences
Department of Animal and Aquacultural Sciences

Contact persons:
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www.foodsofnorway.net

sfi = Centre for Research-based Innovation

The Research Council of Norway

Photo: Knut Martin Løken