DigiFoods

SFI Digital Food Quality

Annual Report 2020

Katinka Dankel, Senior Engineer in Nofima, makes in-line measurements on residual raw material.
• Photo/cc: Jens Petter Wold/Nofima

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Annual Report 2020
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Contents

1. Overall progress and summary for 2020

The global food production is facing enormous challenges in terms of sustainability and food security for a growing population.

Climate reports from IPCC[1] estimates that 21–37% of the total man-made greenhouse gas (GHG) emission is related to the food sector, while 25–30% of all produced food is lost or wasted. As a result, the Norwegian food industry has made an agreement to reduce food loss by 50% by 2030. To reach this goal, one major challenge is to effectively handle and utilize all available food resources of different origin and quality.
The inherent variation in raw material quality reduces process efficiency and increases waste and variation in the final product. The key to reducing waste and increasing profitability is, therefore, to control and utilize the raw material variation in the best possible way.

SFI Digital Food Quality (*DigiFoods*) is a Center for Research-based Innovation (SFI), funded by the Research Council of Norway and the partners. DigiFoods will develop smart sensors for effective food quality assessment directly in the processing lines and in the field. Massive assessment of essential food qualities throughout the value chains will pave the way for a digital transformation of the food production.

Photo/cc: Anders Hansen, Sintef

DigiFoods kick-off had to be digital, due to the pandemic. Nevertheless, the enthusiasm among the participants was great.

1 Intergovermental Panel on Climate Changes, *report 160819*, 53-121 (2019).

The obtained quality information will be used for optimization of processes and value chains making the food industry more efficient and sustainable. In DigiFoods, six research partners, eight food companies and thirteen technology providers are eager and motivated to contribute to actual innovations within food processing, sensor technology and data analytics.

This annual report covers activities during the first three months of the centre, October 1st to December 31st 2020.

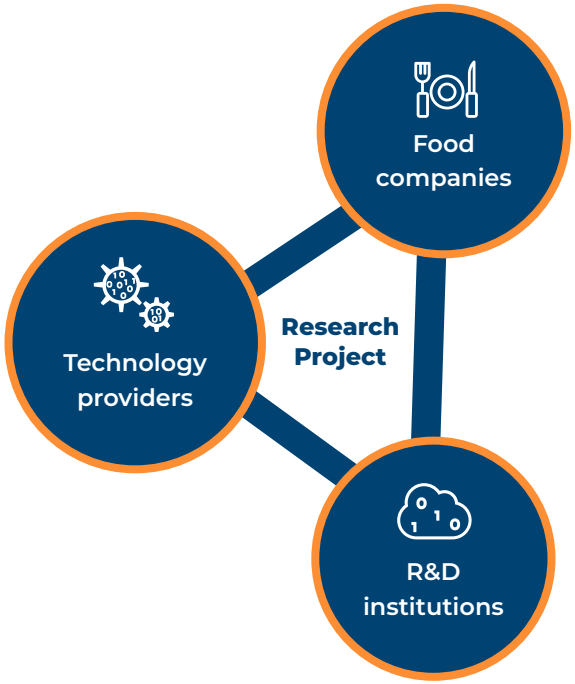
In December, the Board approved the DigiFoods Working Plan for 2021, consisting of 10 research projects, which will initiate the process of realizing the research that was proposed in the SFI application. The plan marks the start of a long-term and ambitious collaboration, and addresses interesting and relevant research with great innovation potential.

During October, the leader team had individual meetings with all partners, where suggested activities were presented and discussed. These meetings were indeed inspiring. It was important for us to find a good balance between long term research and low hanging fruits that also provide important and motivating results in the short term.

We have followed the centre's innovation model, meaning that in each research project we have sought to assign active partners from the three groups: food companies, technology providers and R&D institutions. Together these will consider the needs and business cases, develop and evaluate technology, and hopefully implement and commercialise. The projects cover all the objectives of the centre and span several essential research themes: Sensor development, robotic operation of sensors, strategies for sensor implementation in industry, and process optimisation.

In this report, we provide a brief presentation of each of these research projects. In 2020, research activities were already conducted in the project RAMAN, which is a successful collaboration between technology providers. It is our opinion that this first working plan will ensure a solid and exciting start for DigiFoods and contribute significantly to reach the main goals of the centre.

The DigiFoods innovation model is based on each research task being assigned active partners from all three groups: food companies, technology providers and R&D institutions. Together they will i) consider the needs and business cases, ii) develop and evaluate technology and iii) implement and commercialise.



Jens Petter Wold, the Centre Director of SFI Digital Food Quality, shortnamed DigiFoods, is a senior scientist at Nofima.
• Photo/cc: Jon-Are Berg-Jacobsen, Nofima

A vital part of the centre is the engagement and education of PhD-students and post docs. We have defined suitable tasks for the seven scholarship holders who will work in DigiFoods from 2021, and six of them have already been recruited. We are looking forward to including them in the research projects and, thereby, securing the foundation for successful years ahead in the centre.

The autumn of 2020 was affected by the Corona pandemic. We looked forward to kicking off the centre early in December by gathering all of the partners in Norway. Since this became impossible, we had a good digital meeting. A very important purpose for DigiFoods is, however, to be an innovation hub and a network where the partners can meet, exchange and discuss ideas. For this to happen we need to meet physically. We are looking forward to this in 2021.

Jens Petter Wold
Centre Director, DigiFoods

Vision and Objectives

The goal of SFI Digital Food Quality is to develop smart, sensor-driven solutions that deliver the essential food quality information required for successful process optimisation and digitalization of the food industry.

Food processes are extremely complex and challenging to measure due to the inherent high level of biological variation in raw materials. The development of advanced solutions that are built on a fundamental understanding of food science, will allow the food industry to effectively measure and handle these variations, enabling a ground-breaking digital transformation of the industry.

The **Primary objective** of DigiFoods is to develop digital solutions for food quality assessment as cutting-edge technological basis for optimal food value chains.

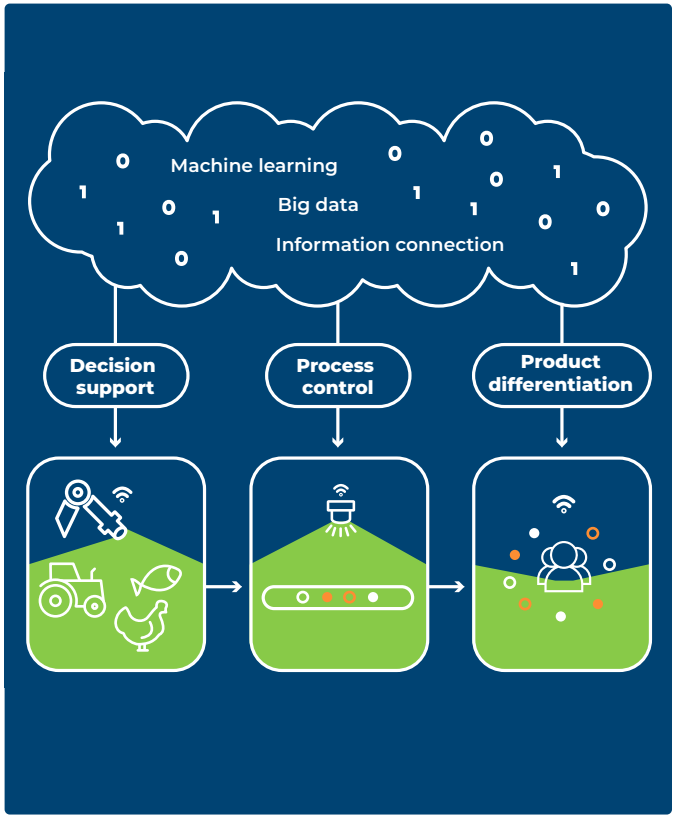
Besides this there are seven **Secondary objectives**:

1. Develop novel in-line sensor systems and applications for measuring critical food quality parameters
2. Develop automation and robotic solutions for enhanced sensor operations in process and in field
3. Develop solutions and strategies for successful sensor implementation in the food production
4. Develop data-driven strategies for process, product and value chain optimisation based on extensive food quality measurements
5. Build and transfer competence in industry and academia and educate master students, 9 PhDs and 3 post docs
6. Foster innovations, patents and spin out companies by the project partners from food industry, technology and research
7. Disseminate knowledge to the industrial sector, the research community, and to the general public

DigiFoods will radically change food production by enabling optimization, control and differentiation based on measurements of *food quality*. The results will lead to a more efficient and sustainable food industry, internationally competitive Norwegian technology companies, and enhanced knowledge transfer and researcher training.

The DigiFoods objectives range from fundamental technology knowledge to practical industry and market implementations, which are equally important for achieving successful innovations. We aspire to bridge the gap between research and industry by building a strong, business-oriented research network of innovation-oriented companies, and national and international R&D institutions. These expected impacts are in line with the centre goals and the overall objectives for the SFI scheme.

The DigiFoods vision: Extensive food quality assessment enables new insights and radical changes from farm to fork.



Milk production is the backbone of Norwegian agriculture

by Wenche Aale Hægermark, Nofima

"Happy, healthy cows, grazing along the fjords and in the mountains, along the coast and inland are some of the most delightful things about Norway." These are the words of Anne Cathrine Whist, who is responsible for Product Development and Research at TINE Meierier and is also the Chairperson of DigiFoods.

It is almost 20 years since Anne Cathrine qualified as a veterinarian. She realised early on that she loved large animals. Especially cows – and helping dairy farmers. Travelling around Norway's regional areas and experiencing how Norwegian cows constitute the backbone of Norwegian agriculture has done something to her.

"Without cows and dairy production our regional areas would have seen little settlement and our cultural landscape would have been a thing of the past. Like much of Sweden, Norway had been regenerated. Milk production still shapes our landscape and our country." She points out that this applies to the whole settlement pattern, which includes small local hamlet schools, sports clubs and local grocery stores – because people actually need something to live off.

Cows – and the wellbeing of farmers

The important role played by dairy production in Norwegian agriculture was a key factor when Anne Cathrine chose her field of research. In her PhD she examined the relationship between udder health and milk quality. She has been leading TINE's research on sustainable milk production for several years, and she is proud of what has been achieved by TINE together with the other cattle industry partners (GENO, Animalia and Nortura) in Norway: strong, healthy cows that require minimum usage of antibiotics.

Many Norwegian dairy farmers have already entered the digital age. Sensors have been installed in many robotically operated cowsheds. These measure conditions such as how cows move in the cowshed, how often they eat, how often they are milked, how long they spend chewing and how long they spend lying down in their stalls.

"The sensors provide farmers with an idea about whether or not the feed is optimal and how the cows are doing. New technologies and sensors, data collection and systematisation will provide even more opportunities. DigiFoods has great expectations in this respect," says Anne Cathrine. The next step is to ensure direct communication between the data produced by the farms and data at the dairy.

Sustainability has three dimensions – Environment. Society. Economics.

Dual purpose Norwegian cattle provide both milk and meat and have a lower CO_2 footprint than pure meat or dairy breeds.

«Without cows and dairy production our regional areas would have seen little settlement and our cultural landscape would have been a thing of the past.»

"We are interested in all three dimensions of sustainability, and these are represented in TINE's sustainability strategy. It is important that both the animals and the farmers thrive. That people living in Norway's rural areas have something to live off. That operations are both viable and environmentally friendly. The greatest greenhouse gas emissions occur in primary industry. We focus on circular reasoning and obtaining an overview of those factors that have the greatest impact on methane emissions," says Anne-Cathrine.

Grass or concentrate feed?

"Sustainability is also about economics. It is important that we find an optimal solution for cows, the environment and the financial situation of dairy producers when discussing feed and feed composition. Proper feeding is important for the fertility, health and welfare of the cows and not least the financial situation of farmers," she says.

TINE has great ambitions in respect of growing feed for dairy cattle in Norway and is working constantly to ensure that the cows will eat as much top quality roughage as possible which has been harvested at the most optimal time.

The composition of the milk is affected by what the cows eat. For example, the fatty acid composition is completely different if the cows only eat grass. This affects both the taste and consistency of TINE's products.

Technology will bring the dairy and farmers closer together

TINE's state-of-the-art, high-tech dairy at Jæren produces white cheese, *prim* (cream cheese), butter, margarine and milk powder. *"There we will be testing and using the sensors and other technology that will be developed at DigiFoods,"* says Anne Cathrine.

The cheese production lines will be equipped with in-line sensors that will measure temperature and pH values, etc. Data from the sensors will be used for monitoring whether or not cheese processing is proceeding correctly or if there are any deviation that would require the process to be stopped and new samples to be taken before the process can be recommenced. This will provide TINE with assurances that the cheese will be just as it should be, with a perfect taste and consistency – always.

"Although we haven't completely thought out the next step, this could involve connecting data from sensors on feed wagons and farm tanks with data from incoming transport, delivery checks and installations. This will provide us with better traceability and control – and the opportunity to make even better use of all the raw materials", concludes Anne Cathrine.

Photo/cc: TINE

Anne Cathrine Whist is the Chairperson of DigiFoods. She has been leading TINE's research on sustainable milk production for several years, and she is proud of what has been achieved by TINE together with the other cattle industry partners in Norway; strong, healthy cows that require minimum usage of antibiotics.

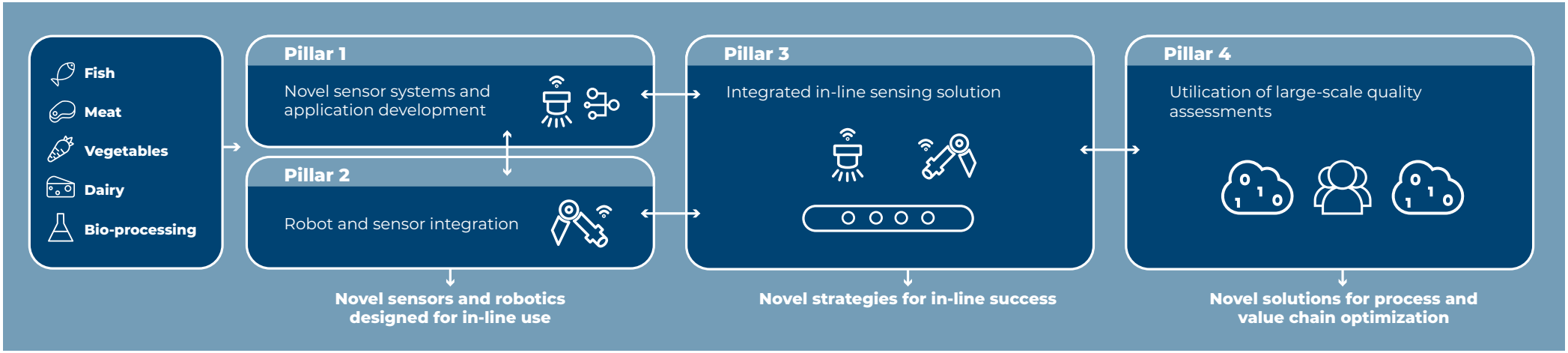
2. Research Plan and Strategy

The main research hypothesis of DigiFoods is that in-line food quality measurements can be used to understand, optimize and radically change food value chains.

The innovations in DigiFoods will be accomplished by combining basic and applied research. A major difference from traditional research in this area lies in the scientific method; prototypes will be tested at the end-users at an early stage, as part of the technology development. This includes large-scale trials in fields, onboard fishing boats and in industrial food process lines, and secures relevance and industry involvement from year one. The research activities are organized in four pillars, and involves value chains for fish, meat, vegetables, dairy and bio-processing (Figure 3). These pillars are not at all silos; some activities will straddle two pillars or more and others might over time progress from one pillar into another.

Pillar 1 will develop novel sensor systems that address critical in-line challenges and industrial needs. Pillar 2 will design novel integrations of robotics and sensors. Pillar 3 will develop strategies for successful implementation of in-line sensors in processes. In Pillar 4, the in-line food quality measurements will be placed in a broader perspective and combined with other relevant data sources to realize improvements at farm, industry and value chain level.

Partner companies representing the major food value chains will define relevant research activities for the four research pillars.



Most of the experimental work in Pillar 3 and 4 will take place in the food industry, in the field or onboard fishing boats. These will serve as important research facilities for securing relevance and usefulness of the technology, and for collecting extensive amounts of food quality data.

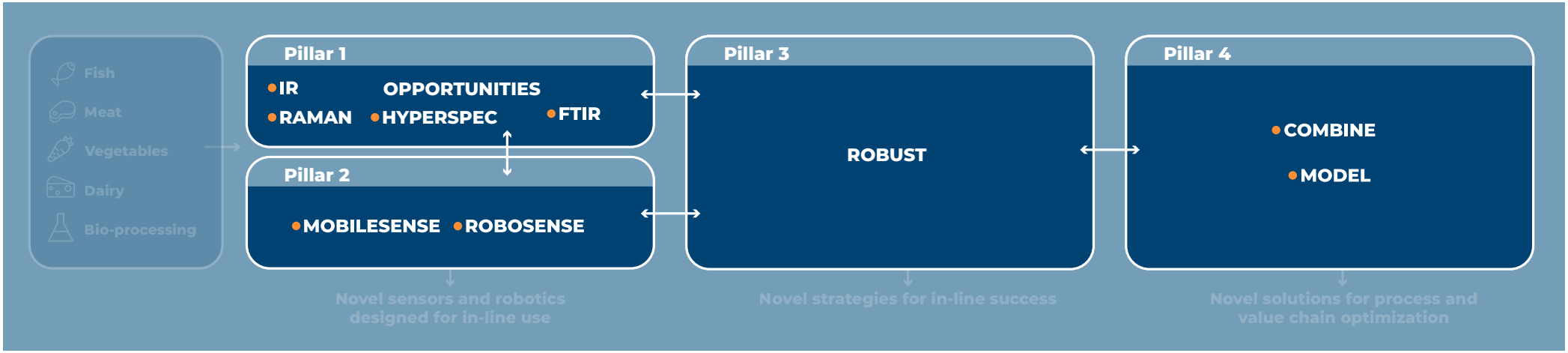
All activities will as far as possible include participants from all three partner groups (food companies, technology providers and R&D institutions) to ensure practical relevance, interdisciplinary and relevant competence. This project organisation is the core of the centre's innovation model, meaning that the partner groups together will consider business cases and innovation opportunities associated with the research.

A thorough process led by the leader team has defined ten research projects, which will initiate the process of realizing the research that was proposed in the SFI application. The projects address the outlined goals and envisioned innovations, targeting gaps in knowledge and technology. All partners have been involved in the planning of the projects, ensuring relevance and securing in-kind contributions through active involvement in the upcoming work.

Projects in Pillars 1 and 2 will collaborate to develop prototype solutions and these will be evaluated for industrial use in Pillar 3, together with already existing sensors. Results from Pillar 3 will also be fed back to Pillar 1 and 2 to optimise and improve the solutions based on in-line performance. Well working solutions developed in Pillar 3 will provide Pillar 4 with essential quality data on an industrial scale.

A Scientific Advisory Board (SAB) has been appointed for DigiFoods, consisting of researchers with competencies in the fields of research in the centre. An important task of the SAB in the years ahead will be to advice during development of the annual plans.

SFI projects allocated in research pillars according to the figure on the previous page. ● For all projects except "Opportunities" and "Robust", PhD or postdoc students will be affiliated



How robots find the best food

by Georg Mathisen for NMBU

Robots that pick the finest berries, and sensors that find the best and healthiest raw produce. New technology will provide us with better food at cheaper prices.

Diseased plants result in bad food. Robots are now learning how to keep plants healthy, ensuring they get the right nutrients and making sure that fruits and vegetables are picked when they are at their best. *"In time, robots will probably be doing as many of the tasks as possible that need to be done out in the fields"*, says Pål Johan From.

Food robots

He is a professor at the Faculty of Science and Technology at NMBU. He leads the work in Pillar 2 Robot and sensor integration.

Not only will it improve the quality of food, it will also make it cheaper and ensure that less is wasted. DigiFoods will develop smart sensor solutions to check the quality of food both on farms and in factories.

Pål's job is all about robots. He wants to see how the robots can make the new sensors better, and he also wants to find out how the sensors can get the robots to do a better job. This will result in robots that can detect disease and determine when it is best to harvest the food.

"For example, we make autonomous robots that operate out in the fields. We can equip them with a lot of different sensors to measure as much as possible and find out more about what is happening in the fields", he explains.

Sugar and fertiliser

The scientists have been working a lot with strawberries. The robots can find out when the berries are ripe and should be picked, detect disease and see if any of the berries are damaged. However, they are now going to start measuring a lot more. The sugar content, for example. The colour of strawberries is usually the best indicator of when they are ready to be picked. However, this isn't always the case. A robot that measures the sugar content of strawberries can see much more than we can.

Other examples: Are plants getting enough nutrients, or do they require more fertiliser? Or do they need to be sprayed, perhaps?

"Currently, we are working on robots that will pick strawberries and treat plant diseases. Once robots are out doing that job, we need to attach as many sensors as possible and measure as much as possible so that we can operate farms in the most efficient manner", says Pål.

«DigiFoods, will develop smart sensor solutions to check the quality of food both on farms and in factories.»

"The majority of time and resources are spent on autonomy. In other words, getting the robot to operate by itself. We use machine learning and artificial intelligence to make robots understand what to do and how to move", he explains.

Healthier and better

The purpose of DigiFoods is exactly what it sounds like: To digitalise Norwegian food production. Better information enables the better utilisation of raw produce. It also ensures that food, and therefore people, become healthier. When we know exactly what affects quality, all the way from farm and fjord to fork, it is then possible to learn from it, produce better food and make the whole process more sustainable.

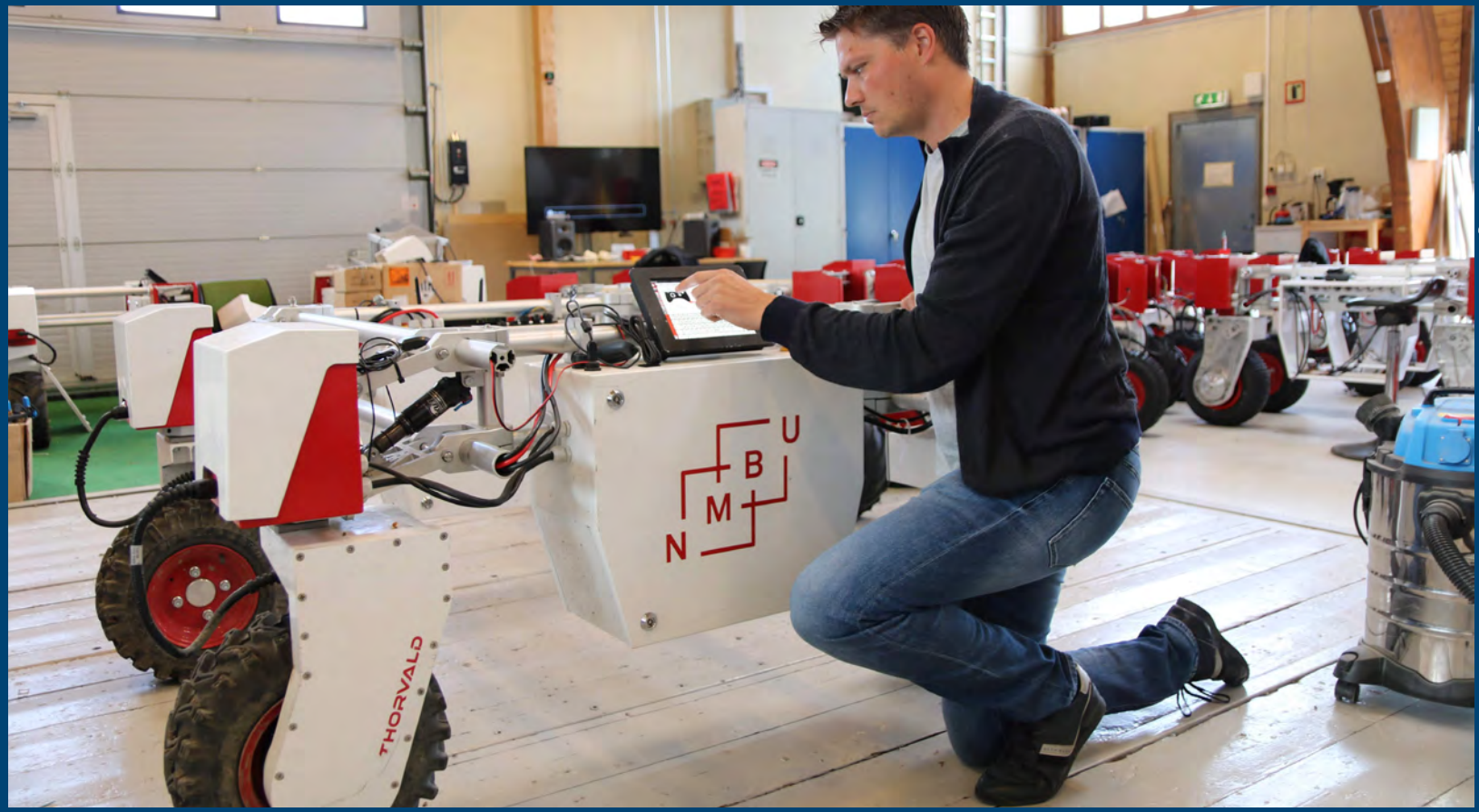
70 to 75% of the price of a food item is the cost of producing the raw produce. Therefore, digitalisation can make good food cheaper. Furthermore, the robots and sensors can help us to throw away less food because the quality improves and the food has a longer shelf life.

Cheaper than people

Finally: Isn't it going to be expensive making robots that are going to cultivate relatively cheap berries, potatoes and vegetables? Not at all.

"The technology is certainly going to be cheaper than paid labour. For a high-cost country like Norway, it will be a great advantage", says Pål. And: Agriculture is struggling to get enough people to do these jobs, especially now that the corona virus has closed the borders during certain periods.

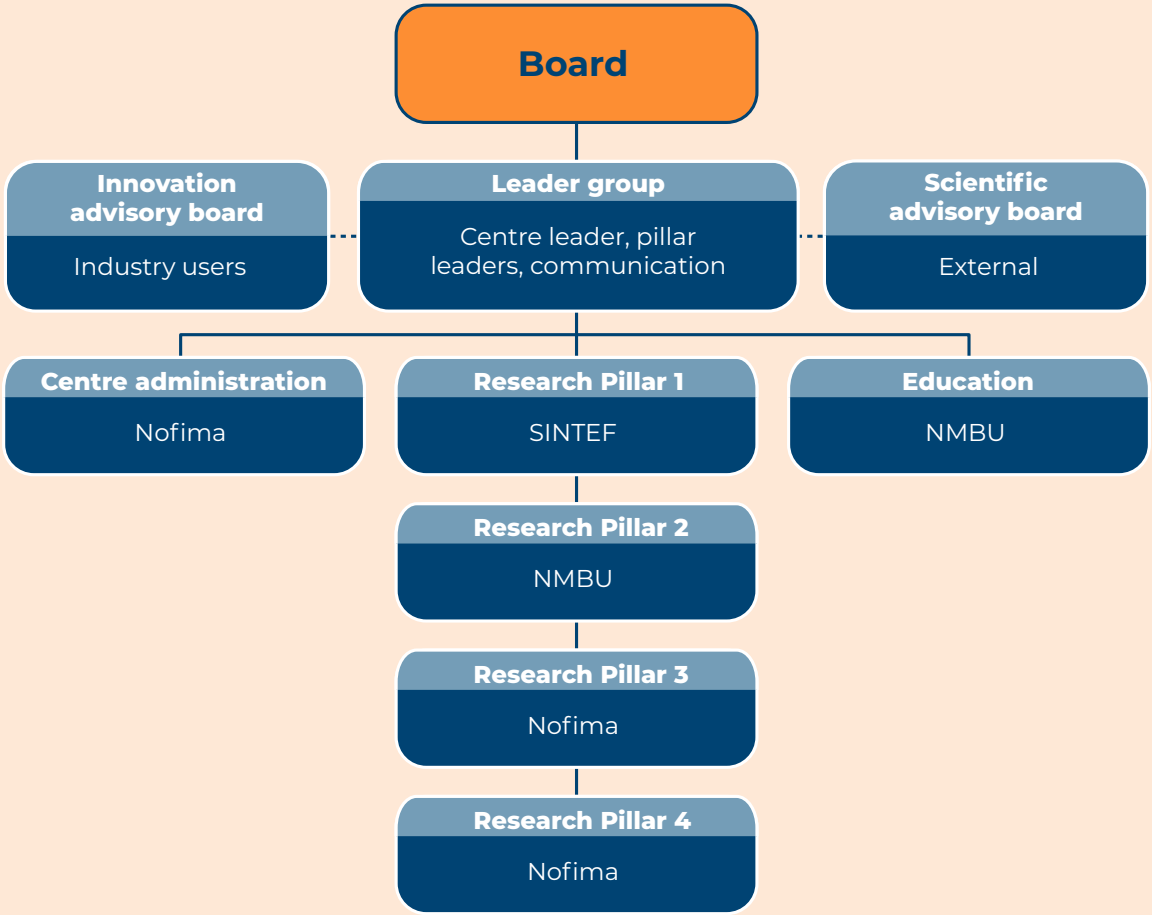
Pål's job is all about robots. He states: "In time, robots will probably be doing as many of the tasks as possible that need to be done out in the fields".



Photo/cc: Dag Idar Jøsang, Norsk Landbruk

3. Organization

Organizational structure, and cooperation between the centre's partners



DigiFoods has a decentralized organizational structure. It's headquarter is at Nofima, Campus Ås. The food industry is by nature decentralized, and Nofima, NMBU and SINTEF have successfully worked together with industry and research partners, independent of their locations.

The DigiFoods Board oversees that obligations are fulfilled, and decide on financial, partnership and IPR matters, as well as ratifying annual research plans made by the leader group. In 2020, the Board met for one digital meeting. The Board consists of the following elected members:

In addition, Mona Gravningen Rygh, the contact person for DigiFoods at the Research Council of Norway, will be an observer at the Board meetings.

The centre scientific work is organised through close collaboration between four Pillars:

- Pillar 1 Novel sensor systems and application development (Lead: SINTEF)
- Pillar 2 Robot and sensor integration (Lead: NMBU)
- Pillar 3 Integrated in-line sensing solutions (Lead: Nofima)
- Pillar 4 Utilization of large-scale quality assessment (Lead: Nofima)

Furthermore, NMBU leads the recruitment and education process in DigiFoods.

The leader group manages and leads DigiFoods, such as ensuring strategic planning and running of projects, recruitment of qualified personnel, providing a good working environment, accounting, dissemination and reporting.

The leader group consists of:

- Jens Petter Wold (Nofima) – Center Director, overall scientific and administrative leader
- Marion O'Farrel (SINTEF) – Scientific Manager of Pillar 1
- Pål Johan From (NMBU) – Scientific Manager of Pillar 2
- Nils Kristian Afseth (Nofima) – Scientific Manager of Pillar 3
- Ingrid Måge (Nofima) – Scientific Manager of Pillar 4
- Kristian Hovde Liland (NMBU) – Manager Recruitment and Education
- Stine Thøring Juul-Dam (Nofima) – Centre Coordinator
- Wenche Aale Hægermark (Nofima) – Communication Leader
- Anne Risbråthe (Nofima) – DigiFoods Controller

The DigiFoods Board

Chairperson of the DigiFoods Board

Anne-Cathrine Whist, TINE

Board Member

Anne Cathrine Gjærde, NMBU

Board Member and representing the host institution

Eva Veiseth-Kent, Nofima

Board Member

Julie Steffensen on behalf of Ingvild Dalen (maternity leave), Lerøy Norway Seafood

Board Member

Mari-Ann Akerjord, Prediktor

Board Member

Mats Carlin, SINTEF

Board Member

Odd Arne Kristengård, Maritech

An external Scientific Advisory Board is appointed and will annually review results and research plans and participate at the annual centre meetings to assist in ensuring scientific quality and industrial and societal relevance. The members are:

- Prof. Søren Balling Engelsen, Dept Food Science, Univ. Copenhagen
- Prof. Bjarne Kjær Ersbøll, Dept. Applied Mathematics and Computer Science, Technical Univ. of Denmark
- Ole Alvseike, Head of division Animalia, Norway
- Onno de Noord, Advanced Data Analysis Consultancy, Amsterdam.

The centre has also appointed an Innovation Advisory Group with representatives recruited from user companies. The members will oversee, evaluate and advice on how innovation processes are promoted and incorporated in the research activities, including knowledge transfer, learning and innovation arenas, as well as industry involvement and business case development. The members are:

- Silje Ottestad, NEO
- Marije Oostindjer, Norilia
- Atle Rettedal, Robot Norge
- Roy Martin Hansen, Lerøy Norway Seafoods

DigiFoods will be organized to facilitate excellent collaboration between three groups of partners: R&D institutions, food companies and sensor, robotics and digital platform companies. The user partners will be involved in the planning of experiments, execution and discussion of results. Research will be conducted in the end-user process lines and require that scientists, engineers and user partner personnel are involved.

The Centre Director and Pillar Leaders, from left Pål Johan From, Jens Petter Wold, Nils Kristian Afseth, Kristian Liland, Ingrid Måge og Marion O'Farrel.

Photo/cc: Wenche Aale Hægermark, Nofima

Frequent meetings are organized at Board level (each six months), Centre level (annual meetings), leader group (every third week), and thematic or project level (as required). In addition to physical and digital meetings, DigiFoods has an internal SharePoint site with a news feed where centre participants can post e.g. news, links to documents, research plans, results, pictures and videos. In addition to a formal news channel, the SharePoint will also act as a social media, thus contributing to build the DigiFoods team spirit.

Photo/cc: Sune Eriksen, Norilia

Bioco, a joint venture between Norilia/Nortura and Felleskjøpet Agri, uses enzymatic hydrolysis to refine poultry rest raw materials. This is an interesting industrial case for the Digifoods SFI, with the goal to improve the process even further

Partners

Per April 1st 2021, DigiFoods has 27 partners, where 6 are R&D partners and 21 are user partners.

R&D Partners

Nofima is one of Europe's largest institutes for applied research within the fields of fisheries, aquaculture and food. Nofima's vision is "Sustainable Food for All", while our objective is to actively contribute to solve the large social challenges such as increased food security, better food safety and health, reduced food waste and reduced environmental and climate foot prints. We have excellent knowledge in food science and are recognized for our research on applied bio-spectroscopy, rapid spectroscopic measurements of food quality, for multivariate data analysis and consumer science over the last 30 years. Nofima is the host institution of DigiFoods and will contribute with peak expertise in applied spectroscopy (Raman, NIR, fluorescence, FTIR and hyperspectral imaging), process analytical technology, data analysis, consumer science and food science. Nofima will also provide an extensive state-of-the-art lab for spectroscopic analysis, food pilot plants and food technology labs. Our key personnel contributing will be DigiFoods Centre Director Jens Petter Wold, Pillar 3 Lead Nils Kristian Afseth, Pillar 4 Lead Ingrid Måge, Senior Scientist Karsten Heia and Scientist Lars Erik Solberg. A group of about 16 scientists and technicians will also take part in the research.

University of Lincoln has established an international reputation for the quality of its research and teaching. Two of the University's leading research centres will participate in DigiFoods, namely the Lincoln Centre for Autonomous Systems Research (L-CAS) and the Lincoln Institute for Agri-food Technology (LIAT). L-CAS specialises in systems integration, bringing together technologies to tackle challenging real-world applications in food manufacturing and agriculture, security, assistive care, and intelligent transportation. LIAT's mission is to develop new technological solutions for the business of producing food through agriculture at all stages of food production including cultivation, harvest, processing and packaging. The undertaken research is strongly applied, with many links to the local, national and global agri-food industry. Our main contribution to DigiFoods will be with our world leading expertise within agricultural robotics. The University will also welcome students, PhD scholars, faculty, and practitioners from industry to spend time in Lincoln with the objective to strengthen collaboration within the centre. We expect that DigiFoods will enable continued collaboration in agricultural robotics and new collaboration in food automation, both with academic and industry partners. Our key personnel contributing in DigiFoods will be Prof. Simon Pearson and Tracey Watson.

Ulm University (UULM) is among the leading 'golden age' universities ranked #3 in Germany, and #18 in the world (Times Higher Education Ranking). The Institute of Analytical and Bioanalytical Chemistry (IABC) operates the Elemental Analysis Center and the Focused Ion Beam Center UULM for Micro/Nano Fabrication/Characterization. IABC provides ample laboratory infrastructure (1,000+ m2), and operates analytical instrumentation including FTIR. IABC has been leading several national and international projects specifically for developing advanced vibrational spectroscopic sensing concepts for industrial, medical, environmental, and food safety applications. In DigiFoods, we will provide our expertise in food quality and safety monitoring/sensing techno-logies, sensing networks, and data mining via advanced analytical techniques and strategies developed at IABC ensuring food safety and public health. Especially, IABC-UULM will develop miniaturized mid-infrared sensing platforms based on thin-film semiconductor and diamond waveguides for analyzing relevant food

constituents and pathogens. We anticipate that this collaborative effort will result in the submission of joint publications and the development of further collaborative research projects. Our key personnel contributing in DigiFoods will be Prof. Boris Mizaikoff.

NMBU's mission is to contribute to the well-being of the planet. Our interdisciplinary research and study programmes generate innovations in food, health, environmental protection, climate and sustainable use of natural resources. As a University, NMBU aims to educate outstanding candidates, perform high-quality research that produces new perspectives, and create innovation. Two research groups from the Faculty of Science and Technology at NMBU take part in DigiFoods: The Biospectroscopy and Data Modeling group (BioSpec group), led by Professor Achim Kohler, and the Robotics group, led by Professor Pål Johan From. In DigiFoods, the BioSpec group will contribute with the development and application of novel handheld and portable infrared devices for quality measurements of food. The Robotics group will contribute with competence in robotics, in particular agricultural robotics, and will develop robots for automation in food processing and sampling. The Robotics group and the Biospec group will collaborate on the development of a robot for automated sample handling for infrared and Raman spectroscopy. The two research groups will supervise several PhD students and postdoctoral researchers in the course of the DigiFoods project. Associate Professor Kristian Hovde Liland from the department of Data Science will be responsible for the education of master students.

SINTEF Smart Sensor Systems (SINTEF) has been developing in-line sensor systems for industry, including the food industry, for more than 30 years, resulting in many process-applied publications and patents of international relevance. SINTEF has specific competence in designing optical measurements systems, based on e.g. spectroscopy, x-ray or cameras and data analysis. A core part of the research involves designing and building robust optical measurement prototypes based on novel measurement concepts, moving as quickly as possible from the lab to the field, and gaining a fuller understanding of the industrial measurement environment. In DigiFoods, SINTEF Smart Sensor Systems will contribute by designing and building new sensor prototypes that are designed for measurement in the industrial process and adapting existing scientific instrumentation to industrial sites for process characterisation measurements. SINTEF will work closely with the PhD students in Digifoods so that they have a greater understanding of the theory behind the sensor prototypes, and make modifications as required. Our key personnel contributing in DigiFoods will be Pillar 1 Lead Marion O'Farrell, Senior Researchers Jon Tschudi, Kari Anne Hestnes Bakke and Trine Kirkhus, and Researcher Anders Hansen and Tim Dunker.

Uni. Valencia The Universitat Politècnica de València (UPV) is the only Technical University in Spain in the top 500 world's most prestigious universities based on the Academic Ranking of World Universities 2018. It is particularly relevant in the areas of Engineering and Sciences and a national leader in patent license income and start-up creation. Multivariate Statistical Engineering Research group was established with the aim of offering the scientific community and the business & technological enterprises a working environment in which to develop research, development and innovation (RDI) in the area of multivariate statistical techniques for quality & productivity improvement. The group is active in Data Analytics, Six Sigma, Process Analytical Technology (PAT), Multivariate Image Analysis (MIA), Process Chemometrics and Statistical Methods for Knowledge Discovery. Our experience working with industry and research-based innovation can be very valuable for Digifoods. On the other hand, getting involved in DigiFoods will provide us an excellent opportunity to be exposed to the needs of the high-tech food industry opening new research lines to get involved. UPV will provide joint supervision of at least one PhD student on data analytics and real-time process control & optimization. Our key personnel contributing in DigiFoods will be Professor Alberto J. Ferrer-Riquelme.

User Partners

Food Companies

TINE SA is a cooperative that processes milk for dairy products and owns some of Norway's largest food brands. Around 10,500 farmers on 8,500 farms are the foundation for TINE's business operations. TINE has Norway as its main market, but also subsidiaries internationally. TINE's strategic goal is to implement Integrated operations (IO) as our future operational standard within dairy production. For TINE, IO means the integration of people, disciplines, organizations, work processes, information and communication technology to make smarter decisions. DigiFoods we will provide us with the opportunity to develop and test technology with deeper research requirements, but also higher potential beneficial outcomes, i.e. a deeper understanding of our raw material - the milk. Our key personnel contributing in DigiFoods will be Director R&D Anne-Cathrine Whist, Technology specialist in Cheese and Start Cultures Jorun Øyaas, Manager R&D Cheese and Fat Products Kjetil Holstad and Technology Specialist Cheese Kjetil Jørgensen.

Nortura is the largest brand supplier in Norway in the meat and egg business, and the company behind the Gilde and Prior brands. We are organized as a cooperative, owned by 17 700 Norwegian farmers that supply raw material to our customers and factories. Nortura slaughters, cuts, refines and develops meat and egg products that are sold to foodservices, retailers and other food related industry with the aim of creating value for our unitholders. Nortura has a strong focus on innovation and R&D and is involved in more than 30 research projects. In DigiFoods we will concentrate our work on our poultry and pork value chains using sensors and big data. We expect to optimize our production and processing lines and hope to get more value out of our raw material. By optimizing processes and products we will achieve higher yield and less food waste and thereby reduce the impact on the environment. One main goal with participating in DigiFoods is to serve our customers and consumers with even better products in the future. Our key personnel contributing in DigiFoods will be Research Director Per Berg, Development Director Atle Løvland and relevant staff from our factories, quality and technical departments.

Norilia refines and sells rest raw materials (plus products), from the Nordic meat and egg industry, thereby contributing to a more sustainable and profitable agriculture. Our biorefinery Bioco uses enzymatic hydrolysis to refine poultry offcuts. There is a large potential for refinement of other raw materials as well, and Norilia has the ambition to implement and industrialize viable processes. This may include new lines using enzymatic hydrolysis on different raw materials, such as bones and offal from pork, beef and lamb, feather or blood, or other processes such as fermentation. In DigiFoods, Norilia will offer our process line at Bioco for development and use of new senor systems and optimization approaches, as well as for pilot and industrial testing. We will also contribute with our competence and know-how on enzymatic hydrolysis, products (raw material, hydrolysates, fats and sediments) and markets (pet food, food and dietary supplements). DigiFoods will be a great platform to develop new knowledge and tools that will enable us to realize our ambition to add more value to our plus-products. Our key personnel contributing in DigiFoods will be Director Business Development Heidi Alvestrand and Chief Advisor Bioprocesses and Business Strategy Marije Oostindjer.

Lerøy Aurora is a world leading company in salmon and trout farming and slaughtering, as well as the manufacture of products based on these raw materials for the consumer market. We have long experience with handling large amounts of fish, both in the fish farms, through the slaughter process and in production of consumer products. Our overall strategy is to secure a sustainable economic future for fish farming and production, both locally and worldwide. DigiFoods represents a unique opportunity to share knowledge and learn from other companies. The possibilities for new knowledge and innovations seem very promising and can be both of a generic nature (sector independent) as well as specific for our business. Our key personnel contributing in DigiFoods will be Factory Manager Tore Pedersen.

Biomega was founded in 2000 on the premise of advancing innovative biotechnology to release the full nutritional and functional value of otherwise underutilized side streams from the salmon industry. Today, Biomega has a rich patent family of various technologies, with the continuous enzymatic hydrolysis process at its core. We continuously invest in innovation through R&D to ensure best-in-class technology and respond to customers' needs, including product development, traceability, and sustainability. In our Norwegian biorefinery we turn food-grade fresh salmon raw materials into premium feed and food-grade ingredients. Sophisticated biorefining processes ensure careful separation of nutritional components. Biomega's mission is to transform undervalued raw material into premium food and petfood ingredients through accelerated biorefining. In DigiFoods, we will be an industrial test facility for new in-line monitoring solutions, and our expectations is that along the DigiFoods lifespan new in-line process monitoring equipment is devolved that could contribute to a more stable production and end-product quality. Our key personnel contributing in DigiFoods will be CTO Andrew Dustan and Director of R&D Bjørn Liaset.

Hoff SA is Norway's largest potato processing company, processing 1/3 of Norway's potato production. Hoff is producing a range of different potato-based food products and food additives, such as e.g. pommes frites, mashed potatoes, potato starch, potato glucose syrup and potato spirits. We believe that DigiFoods can help us solve specific challenges related to variations in potato quality, in addition to generic challenges related to technology and data handling. Hoff wishes to make use of in-line measurements (NIR) either at intake of the potatoes or during processing. The NIR measurements will hopefully give us useful information concerning process control which in turn, and in combination with our participation in the projects ROBUST and MODEL, can help us develop a statistical process control (SPC). We also see great value in sharing knowledge and learn from other food companies with similar challenges. Our key personnel contributing in DigiFoods will be Process and Product Development Manager Ingvild Sveen.

Lerøy Havfisk is a large trawler company in Norway. We have long experience in handling large amounts of fish and facing quality challenges in whitefish production, with highly skilled personnel. Our strategy for improved handling of fish is making it possible to sort fish into different quality grades. These are key factors, as we see it, in order to secure a sustainable economic future for the fishing fleet and the land-based seafood industry. DigiFoods represents a unique opportunity to share knowledge and learn from other companies. The knowledge and innovations to be generated can be both of generic nature (sector independent) as well as specific for our business. It is hard to see that all outlined innovations can be established without this joint initiative. Our key personnel contributing in DigiFoods will be Operation Manager Odd Johan Fladmark.

Lerøy Norway Seafoods is Lerøy's quality brand for sustainable whitefish caught in the wild – and sourced from the Arctic seas in the north. The very best raw ingredients are picked, processed and packaged, then distributed to markets worldwide. With a history of more than 140 years of fishing in these waters, it is safe to say that our products are the result of developing and preserving a proud craft. Our main activities are within processing for filet products and ready-to-eat meals. Lerøy has high focus on improving the utilization of our raw material and thereby reduce food waste and increase profitability as well as consumer satisfaction. Assessing key quality properties by advanced sensors will help achieving this, and by combining data from different sources – knowledge and improved processes can be obtained. In DigiFoods, we will contribute with user expertise and production lines and we see this as a unique opportunity to discuss innovation ideas and improvements for our quality development work, e.g. sensors that are easy to use, practical and cost efficient. Our key personnel contributing in DigiFoods will be Quality Manager Rune Hansen, Project Manager Julie Steffensen, Leader Technology Project and Business Development Ingvild Dahlen and Quality Lead Raw Materials Whitefish Roy Martin Martinsen.

Sensor & Robotic

Prediktor Instruments develops and delivers advanced sensors and associated software for industrial applications. Our instruments are based on Near Infrared spectroscopy and designed for in-line mounting for the purposes of continuous monitoring, process control and optimization. Important customer segments are food, feed and dairy industries, with common needs for controlling their processes, minimize the expenses and achieve optimal product quality. In DigiFoods, Prediktor will actively take part in the research activities, and we will also contribute with relevant equipment (sensors) for the field trials. We foresee that being part of a long-term research center together with the research organizations, food companies and other technology providers will be of great value for our business development in general; through networking, increased understanding of the customers' needs and challenges, and opportunities for collaborations and sharing of experiences with a wide range of technology suppliers. Our key personnel contributing in DigiFoods will be CPO Mari-Ann Akerjord, CSO Terje Karstang and CSO Dag Martin Romslo.

NEO Norsk Elektro Optikk AS is a privately owned research company within the field of electro optics. NEO's main commercial interest is within hyperspectral imaging. Our line of hyperspectral cameras (HySpex) is recognized as the most advanced and accurate hyperspectral instrumentation available in the market. Through the SFI we want to develop new methods for applying our hyperspectral imaging technology to different food industry applications and to develop integral customized solutions. We could also be interested in designing dedicated instruments for one or more of the food partners both within imaging and point spectroscopy. Our main contribution in the SFI will be testing the suitability of our instrumentation for measuring different food quality parameters. We have our own camera lab and expertise within data analysis. Rental of instrumentation for use by other partners will also be one of our main contributions. We expect that DigiFoods will allow us to gain a better understanding of the need for spectroscopic information within the food industry and that this will help us identify new commercial opportunities within our field of expertise. Our key personnel contributing in DigiFoods will be Senior Research Scientist Silje Ottestad, Hyperspectral Applications Manager Julio Hernandez and CEO Trond Løke.

RobotNorge was established in 2003 as a private spin-off from ABB Robotics at Bryne. The history goes back to the root of robotics in Norway, ie the development of the first paint robot in the 1960s. Now, RobotNorge develops robotic solutions for future production needs. New technology that advances sensory, camera and AI is combined with traditional, industrial ABB robots. Our vision is to actively participate in creating a profitable and sustainable production industry in Norway. Over the past two years, RobotNorge has stepped up activities within food handling and production. Recent developments within sensor/vision technology, AI and robotics control, provide potential for a new range of advancements and better solutions for the food industry. We believe that DigiFoods has the potential to become an important enabling Centre and a catalyst for these developments and foresee a Centre which can provide context, network, shared experience, distribute research project results and give support to new initiatives. Our key personnel contributing in DigiFoods will be Chairman Atle Rettedal.

nanoplus focuses on the development of customer specific optoelectronic devices for sensor applications and has significant experience with complex coupled distributed feedback (DFB) laser diodes, but also the GaSb material system and associated challenges like water-free chip processing. nanoplus will in particular contribute to Digifoods by bringing in capabilities and related expertise in the field of ICL and QCL technology. DigiFoods will enable us to maintain a strategic position with respect to emerging technology and related market opportunities concerning infrared emitters in the food industry field, and to related investigations for future device applications in biophotonics. Our key personnel contributing in DigiFoods will be Johannes Koeth.

MarqMetrix offers a simple, stable and powerful Raman spectroscopy platform built for field and process applications at a performance level previously available only in costly lab instrumentation. We make affordable solutions that operate at scale to monitor and control processes in real-time for efficiency and quality optimization. Our fast and non-destructive sampling technology allows you to simply “touch” a sample to analyze gasses, liquids, solids and slurries. MarqMetrix has years of experience using Raman spectroscopy for analyzing lipids, collagen, and carotene concentrations in salmon fillets and cooking oil. We are excited about our participation in DigiFoods because it will enable close collaboration with food companies and third parties to innovate and broaden the applicability of Raman technology in the food and beverage industry. Our key personnel contributing in DigiFoods will be CEO Brian Marquardt, VP of Data Analysis Thomas Dearing and Senior Application Scientist Bharat Mankani.

Saga Robotics develops robots for the agricultural domain. We have developed the Thorvald platform which is a modular and completely autonomous robot that carries out a wide variety of agricultural tasks. The modularity of the robot allows us to operate in open fields, greenhouses, and polytunnels where the robot uses advanced sensor systems and machine learning to navigate autonomously in the field. A very specific outcome that we expect from DigiFoods is a close collaboration with developers of sensors and tools that have products or can develop new products that they would like to put onto our robots to collect large amounts of data that has not previously been available to farmers or researchers. We look forward to sharing our knowledge and experience in the DigiFoods partner network and see this as a good basis and opportunity to discuss innovation ideas. We will also offer an autonomous robot for field trials with sensors. Saga will work on integrating sensor systems on field robots and to test these in the field. Our key personnel contributing in DigiFoods will be CCO Ellen Altenborg, CTO Lars Grimstad and CEO Pål Johan From.

OptoPrecision GmbH is a small, yet leading company in research, development, and production of high quality optical sensing devices. Today, we address with our products applications in the chemical and steel industry, security and observation business and also in the pharmaceutical market. The strategic goal of OptoPrecison is to strengthen and expand its business via network actives with research institutes and complementary companies to new fields of applications based on the adaption of already available in-house solutions as well as the joined development of new technologies. In DigiFoods, we will contribute in terms of developing multi-purpose driver electronics for different infrared emitters (LEDs or lasers) and detection electronics as well as the corresponding embedded software to operate these circuit boards for the development of novel sensing technologies proposed herein and for the realization of a dedicated analyser platform. DigiFoods provides a partner network and an excellent basis and opportunity to discuss and push innovative ideas to the market. Our key personnel contributing in DigiFoods will be Markus Naegele.

Digital Platforms, software and analytics

CAMO is a leader in industrial analytics and the preferred partner for industry leaders digitizing their value chain. With a world class industrial analytics platform, we help companies optimize their processes, drive better product quality and efficiency through innovative analytical solutions. Founded in 1984 by Norwegian scientists, Camo has applied analytical science to process and product quality problems for decades. The DigiFoods research centre will address the current knowledge and technology needs to achieve a successful digital transformation of the food industry. This is consistent with the strategies of our organization, where as part of our goal of bringing insights from science-based industrial analytics into daily operations, the food industry has been an important market for us for many years. Through the DigiFoods partnership, we will gain valuable insight that will help us guide the development of our solutions so they best fit the needs of the food industry. Our key personnel contributing in DigiFoods will be Geir Rune Flåten, Leslie Euceda Wood and Lars Gidskehaug. Camo was acquired by Aspen Technology, Inc in November 2020.

Idletechs AS was founded in order to stimulate the digitalization in the industry. We develop fundamentally new tools for people-oriented, understandable artificial intelligence. In DigiFoods we intend to stimulate to deeper understanding, creative innovations and more robust in-line implementations of modern multichannel quality monitoring instruments, as well as to supply software for quality monitoring, deliver hyperspectral software in the food production chain and simplify the integration of multichannel sensor data from various sources in the food production sector. DigiFoods will provide important market contacts and user feed-back for Idletechs and enable us to position us in the market. Our key personnel contributing in DigiFoods will be CEO Andreas Wulvik and Project Manager Frank Westad.

IBM is a leading global technology company engaged in 170 countries and is transforming to become a global cloud platform and cognitive solutions company. For our clients, these tools and technologies help them improve and work in smarter ways, improving production and operations, and gaining competitive advantage. We conduct research and development in the field of digitalization and blockchain technologies for the area of food production and distribution. In DigiFoods IBM will foucs on enabling centre innovations and allow our partners to interface and integrate with the IBM Food Trust platform, and thus enable a value add way to scale up innovations for a global market. In addition IBM can, if needed, engage in the utilization of large scale quality measures, where large data volumes are collected and analysed to produce actionable insight for end users. We will then engage with relevant skills and technology and the IBM cloud platform, development tools, AI and blockchain technologies can be used to develop and test new, innovative technical concepts and solutions. Our key personnel contributing in DigiFoods will be Chief Technology Officer, IBM Norway Loek Vredenberg and IBM FoodTrust Europe Espen Braathe.

Maritech Systems AS develops and provides software and data collection solutions to the growing seafood industry. Today, Maritech is the market leader for business solutions for the seafood industry, with a market share of 80% of the traders, 50% of processing fisheries and 80% of food fish. 70% of fish exports from Norway goes through the Maritech software systems. In addition to moving the existing software solutions from on-premise programs to a cloud-based software solution, we aim to develop novel software solutions for the seafood industry. We believe that collaborations between the industry and research institutions are crucial for innovation. Partnership in DigiFoods will enable us to cooperate with partners that experience similar challenges in other food industries and partners that have experience with the tools that can be applied to help us develop new decision support solutions for our customers and thereby increase the value of our portfolio. Our key personnel contributing in DigiFoods will be CEO Odd Arne Kristengård, Data Scientist Helene Seyr, VP Data Science Oddvar Husby and Director IoT Andre Lillebakk.

CGI was founded in 1976 and is among the largest IT and business consulting services firms in the world. Operating in hundreds of locations across the globe, CGI delivers an end-to-end portfolio of capabilities, from strategic IT and business consulting to systems integration, managed IT and business process services and intellectual property solutions. CGI contributes to the design and development of physical solutions for both the agri- and aquacultural domain in close collaboration with our customers and has a business strategy focusing on FoodTech. The focus has been on business concepts and solutions for securing sustainable food production and animal welfare, e.g. by using computer vision to capture and analyse animal behaviour. CGI is an ambitious company that wants to drive innovation through emerging technologies and new business ideas. Through the DigiFoods partnership we intend to engage in both physical product design and prototyping, as well as IT/software solutions enabling us to put research into action through new innovations. Our key personnel contributing in DigiFoods will be Director Wilhelm Holmen, Consultant Simen Tofteberg and Junior Consultant Aslak E. Svensson.

Intelecy is a software company creating software for advanced analytics for process and production industry. Intelecy has created software for analyzing multivariate event driven and asynchronous timeseries data which is the characteristics in industrial sensor data. Intelecy also handle data ingestion from “factories”, cleaning data, labeling data and orchestration of how sensor relates to assets or production lines. For Intelecy, Digifoods will be a place to learn and share knowledge with a larger community and be able to test how well machine learning algorithms will perform against more traditional approaches. Our key personnel contributing in DigiFoods will be COO Espen Davidsen and CEO Bertil Helseth.

“There is no doubt that DigiFoods will play an important role in our innovation work in the years to come”

Odd Arne Kristengård,
CEO Maritech

Article by Anne-May Johansen, Nofima

Light-based quality analysis of whole fish can revolutionise the Norwegian fishing industry. The new technology is the result of close collaboration between scientists, technologists and the fishing industry.

Maritech Eye is the name of the new product family. Species and blood identification of whitefish enable fish producers to find out whether they have bought top-quality fish even before they are gutted.

Safer and more sustainable food production

On Monday 23 November 2020, Maritech, Nofima and Norsk Elektro Optics (NEO), in collaboration with fishing industry companies Lerøy Norway Seafood and Lerøy Havfisk, were able to launch Maritech’s solution for hyperspectral quality analysis. The successful collaboration in the KVASS research project (Automated quality assessment of headed/gutted whitefish) has now led to Maritech becoming a key partner in DigiFoods..

“We see our participation in active partnerships with key research institutions as being very valuable. DigiFoods strengthens our work on research and development, and is a key driving force for innovation, learning and sharing of expertise between different industries and disciplines. This benefits both us, our industry and Norway as a whole, and contributes to safer and more sustainable food production from a global perspective”, says Odd Arne Kristengård, CEO of Maritech.

Photo/cc: Lars Åke Andersen © Nofima.

Minister of Fisheries and Seafood Odd Emil Ingebrigtsen joined Nofima scientist Karstein Heia for the official launch of the solution, which has been named Maritech Eye.

He points out that heavyweights within the fields of food production and technology are involved, giving the collaboration clout and making it a natural arena for Maritech to be a part of.

"We would also like to highlight the exciting collaboration between green and blue industries, which provides interesting perspectives on further opportunities across sectors. There is no doubt that DigiFoods will play an important role in our innovation work in the years to come", says Kristengård.

Big deal

For decades, Nofima scientist Karsten Heia has been working on the development of the technology that has resulted in Maritech Eye. The first time he attempted to assess fish quality by using imaging spectroscopy was in 1997. Back then, it took half an hour to measure a 10 x 10 cm skinless piece of fish. Now, Maritech Eye can assess whole fish at industrial speeds.

"Being able to utilise imaging spectroscopy in an industrial setting is a major milestone for me as a scientist, for Nofima as a research institute and for the Norwegian fishing industry. The fact that we, an institute for applied research, with funding from the Norwegian Seafood Research Fund, can contribute to boosting the Norwegian business sector in terms of both technological developments and innovations in the food industry, is a big deal", says Karsten Heia.

Maritech is the largest global software provider to the seafood industry, and has developed the machine which is now ready for commercial sale. Norsk Elektro Optikk (NEO) has developed the hyperspectral camera used for the quality assessment of whole fish. The industrial trial was carried out at Lerøy Norway Seafood's Båtsfjord facility in Finnmark.

"The collaboration has been extremely constructive, very close, and is a big part of the reason why we are where we are today", says Odd Arne Kristengård.

"We would like to commend Nofima and NEO for being as on the ball as they have been, and we would also like to praise the initiative taken by Lerøy, and the willingness and courage of all the organisations to really go for it and do something they are not used to", he says.

Enthusiastic minister

Minister of Fisheries and Seafood Odd Emil Ingebrigtsen was responsible for the official launch of Maritech Eye. He is thrilled with the collaborative research that has taken place.

"The project is a prime example of what is possible when the business sector and research communities collaborate on technological innovations. Better quality sorting is positive for both the profitability and reputation of the Norwegian seafood industry", says Ingebrigtsen.

Futher on

Due to the fact that the Maritech Eye solution is compact and suitable for the industry, it provides a solid beginning for developing new innovations in DigiFoods.

As Nofima has been a significant partner in developing the solution, and therefore knows it very well, new applications can be tested efficiently, says Karsten Heia.

Photo/cc: Elin Herjehagen, Anunatak

Senior Scientist at Nofima Karstein Heia together with Maritech's KVASS project manager Nils Petter Farstad and IoT architect Jan Rune Herheim, have worked closely together on the development of the new technology.

4. Scientific activities and results

Pillar 1 Novel sensor systems and application development

In this Pillar, we will focus on the development of new sensor systems that will enable in-line measurement of food quality features that are not possible today.

We will explore solutions that are based on high-resolution spectroscopy, imaging sensors and low-powered spectral sensors. There are several industrial partners in DigiFoods that are at the forefront of developing in-line food measurement technology, and in 2021 we will start a range of research projects that focus on developing new in-line applications using hyperspectral imaging, FTIR, Raman and IR.

All of these new applications will be explored in partnership with both end-users in the food industry and potential technology providers with the potential to realise results into a commercial product. The research partners in these projects bring with them expertise in sensor design, applied spectroscopy, machine learning and food science, and will take primary responsibility for supervising the PhD students. Another activity in Pillar 1 is the exploration of new opportunities, for brainstorming and discussing new ideas and feasibility studies.

Pillar 1 is led by Senior Scientist Marion O'Farrell at SINTEF Digital. Key partners in this Pillar include Lerøy Aurora, Lerøy Seafoods, Lerøy Havfisk, Nortura, Norilia, Biomega, TINE, MarqMetrix, nanoplus, Prediktor and Nofima.

FTIR

FTIR generates highly resolved, information-rich spectra. In this project, the focus will be on the determination of more complex food quality parameters in industrial applications, such as specific fatty acids and proteins in dairy processes, or measurements for controlling bioprocessing of residual raw materials. Since water in aqueous solutions efficiently absorbs some of the wavelengths in FTIR spectra, dry-film analysis is particularly interesting for protein characterization, since multiple protein-related infrared absorbances are "buried" when water is present in the sample.

One of the first steps in this research project will be to develop a portable FTIR system for dry-film measurements that can be brought close to industrial process lines, enabling industrially relevant measurements. SINTEF will take responsibility for developing this instrumentation.

By the end of 2021, the goal is to have collected sufficient FTIR data for the first PhD-paper related to how sample preparation affects FTIR analysis of protein-containing liquids. This will ensure that we have a portable FTIR system that has been tested in the laboratory, making it ready for testing in industrial environments.

Handheld and portable IR

This project is tightly related to the FTIR project. The work in 2020 was mainly related to planning 2021, and this was done in close collaboration with other research partners and industry. IIn this part of the centre, we will use sensor technology that is under development in two on-going ICT photonics projects, for different applications. We will adapt them for food quality measurements in Digifoods. We have planned to set up the optical components in preparation for two prototypes in the spectroscopy lab at NMBU. One of the prototypes will, at the end of the development, be the size of a mobile phone, and will be used for quality monitoring tests. The other prototype will be larger and likelly be used for reference analysis. The monitoring prototype will be the first setup to establish in the lab in 2021 and will be based on LED technology from partner nanoplus. It will be assembled in collaboration with research partner Ulm University and partner OptoPrecision. The instrumentation will be tested for different quality scenarios that are relevant for food producers in the centre. The obtained data will be further transferred to and integrated into platforms such as the block chain-based IBM Food Trust™ data platform for tracing food contamination and improving food quality.

RAMAN

The project RAMAN will study how Raman spectroscopy can measure quality parameters such as fatty acid and protein composition in different foods. The focus of the project will be on novel sampling strategies and the use of state-of-the-art technology to reduce sampling time and make Raman suitable for process measurements. Raman spectroscopy shows great promise for future smart food sensor systems. Raman relies upon inelastic scattering of photons, known as Raman scattering. The method is gaining increasing interest for its ability to capture subtle chemical distinctions in foods. Recent feasibility studies show how the techniques can be used to quantify complex food quality features such as fatty acids in muscle foods, sugars in apples, and mineral and bone contents in meat slurries.

In recent years, robust and more low-cost Raman instrumentation has become available. The goal of our partner MarqMetrix is to develop and provide affordable and practical in-line sensor solutions also to the food industry.

HYPERSPEC

will continue on-going R&D on the industrial application of hyperspectral imaging, with a long-term emphasis on achieving robust measurements using lower-cost cameras. The main focus in 2021 will be to improve the modelling of interaction between light and sample tissue. Furthermore, to test a set of different applications based on Maritech Eye and point measurements.

Combining hyperspectral imaging with 3D-laser measurements solutions for colour, fat, melanin and cutting errors in salmon fillets will be tested. Fatty acid composition will be addressed together with the RAMAN project where focus from HYPERSPEC will be on the applicability of hyperspectral imaging in the SWIR region as an alternative to Raman spectroscopy.

Photo/cc: Sintef

Sensor prototypes for measuring for instance chemical complexity in food samples will be build and tested.

Based on hyperspectral imaging and point measurements a feasibility study will be conducted on detection of soft tissue (Jelly-fish) in Greenland halibut (Reinhardtius hippoglossoides). The same will be tested for whitefish. In both cases the fish will be measured before cutting into fillets. In this work also protein, fat and water will be addressed.

Automated decapitation and cleaning of round fish is a widely used practice onboard fishing vessels. Tests will be conducted to combining Maritech Eye and 3D laser scanning for automatic identification of cutting errors and improper cleaning of the belly cavity.

Post Doc Samuel Ortega Sarmiento will work on strategies for combining Magnetic Resonance Imaging and other reference methods for robust industrial applications of hyperspectral imaging, as well as improving physical modelling tissue/light interactions.

OPPORTUNITIES

This project will give the centre the opportunity to incorporate new ideas and needs for rapid in-line quality measurements into the project, or to modify their initial ideas based on what we learn along the way. This project will give us the chance to investigate possible novel applications based on present and future ideas and needs. New technology is being constantly developed in universities and research institutes, or is being made commercially available on the market, or it is falling to a more reasonable price range. It is important for the partners in DigiFoods to have an overview of these opportunities, so they can pivot and adapt accordingly, seizing new opportunities as they arise.

Nofima will take responsibility for developing new application concepts from the end-user perspective and SINTEF will be responsible for coordinating tracking of new enabling measurement technology, e.g. through conference attendance, organising workshops and generating technology roadmaps. NMBU will also partake in these activities.

In 2021, the goal is to deliver an overview of new application possibilities that arise, a summary of exploratory work on a selected technology of interest, and a roadmap of new spectroscopic technology that can be of interest.

• Photo/cc: Kristoffer Skarsgård, Saga Robotics

Pillar 2 Robot and sensor integration

Robots and sensors are important in several different areas of the food industry. The rise of the agri-tech sector has shown a demand for robots and sensors to work closely together to increase the performance and accuracy of production both in outdoor and indoor systems.

In this pillar, we will look at how robots can be used to enhance the performance of sensors by accurate positioning of sensors for optimal sample taking and measurements. We will also look at how sensors can be used to increase the performance of robots and improve decision making process and overall performance. We will develop fully autonomous robots and automatic sample preparation and enable in-line measurement of heterogeneous foods by robotic control of smart sensors.

In this work, we will develop automatic samples preparation for high-throughput spectral fingerprinting of biological liquid samples by FTR and Raman, which is closely related to the work done in the other pillars. The work will develop fully automated robotic systems for separating phases such as microbial biomass from media and protein solutions. We will test the solutions in fully automated screening micro-cultivation systems and different scale bioreactors. Machine learning and advanced AI is used to optimise the sample preparation and provide improved and more efficient measurements.

The research area is led by Prof Pål Johan From at NMBU and divided into two main projects. Key partners in this pillar include Saga Robotics, Robot Norge, TINE, Prediktor, Hoff, Norilia, BioMega, Nofima, SINTEF and University of Lincoln.

ROBOSENSE

The aim of this work is to enable in-line measurement of heterogeneous foods by robotic control of smart sensors. We will develop new robotic techniques to optimize the performance of current and new sensors mounted on robotic arms. Robot arms can use sensory input to accurately position the sensors to guarantee optimal measurements of food that vary in size and shape. This will give a more reliable and robust set of data and can be used to build better models and analytics. We will develop new prototypes for use under real process conditions, i.e., in processes that have a very high throughput and high requirements for speed and reliability. The sensors to be used in this work will be developed in close collaboration with the other pillars in DigiFoods.

MOBILESENSE

The purpose of this work is to develop fully autonomous robots for automatic collection of large-scale quality data in the field. We will integrate a suite of sensors on the Saga Robotic's Thorvald mobile platform for exploration purposes in open fields. This will give large amounts of data over time and space and increase our understanding of how to collect and analyse date in the agricultural environment. As a part of this work, we will develop autonomous robots for measuring quality features in potatoes using NIR and investigate how to use sensory input to predict yield and quality on strawberry farms.

Photo/cc: Kristoffer Skarsgård, Saga Robotics

Photo/cc: Kristoffer Skarsgård, Saga Robotics

The Robot Thorvald is a fully autonomous robot. New robotic techniques will be developed to optimize the performance of current and new sensors.

Pillar 3 Integrated in-line sensing solutions

When a food sensor has been developed in a controlled environment, there is still a long journey to industrial implementation. Several commercial food sensors have failed because they were not robust towards the inherent bio-variability encountered in the processes and products.

Strategies that address the practical and theoretical considerations for sensor implementation is clearly needed, both for the instruments that are already used commercially, but not least for techniques with very limited industrial use, such as FTIR, Raman and fluorescence spectroscopy.

In Pillar 3 we will develop and validate efficient solutions and strategies for successful sensor implementation in food production. Put in other words: We will make the sensors actually work in the food companies. We will develop the appropriate tools for robust calibration of real-time industrial sensor systems, meaning enabling the sensors to actually provide the user with reliable quantitative outputs.

Food handling and processing is indeed complex, and one sensor is not always enough to provide sufficient information on a particular process. Therefore, we will also develop novel combinations of sensors to provide more comprehensive and precise food quality information. Last, but not least, we will use implemented sensors to explore and map variation in food processes over time.

Many of the sensors proposed in DigiFoods will provide previously unavailable information from food processes. We will document and map quality variations along processes and over time with in-line sensors, evaluating the potential for process improvements, real-time process control and product differentiation.

Pillar 3 is lead by Senior Scientist Nils Kristian Afseth at Nofima. Key partners in this Pillar include all food partners, NEO, Camo, Prediktor, Marqmetrics, Idletechs, Sintef and NMBU.

ROBUST

A major bottleneck for industrial sensor implementation is to get from the measured signal to reliable estimates of food quality attributes. A robust calibration model needs to handle chemical and physical sample variations as well as harsh and changing surroundings. Spectroscopic sensor technology has many application areas in in-line food quality analysis.

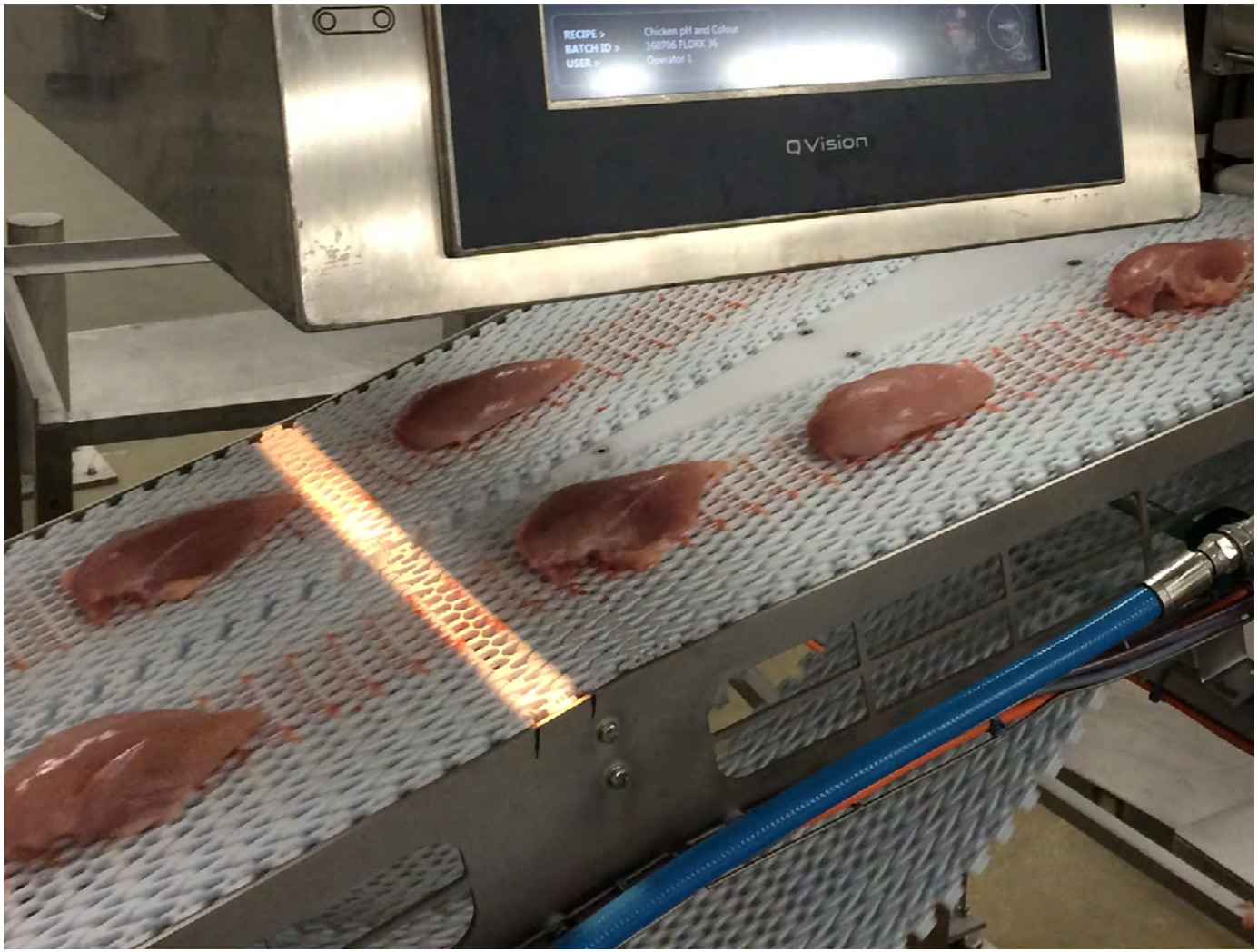
Some applications are well established, and robust calibration models can be purchased from instrument vendors. New or less standardised applications require development of new calibration models, which can be a time consuming and expensive task. Also, it is

“We will make the sensors actually work in the food companies.”

frequently necessary to maintain models over time for both instrumental, environmental and process reasons.

In ROBUST the main aim is to define strategies and methods for efficient and robust calibration and maintenance of in-line spectroscopic instruments. This will be based on collecting relevant calibration and process data from in-line processes at selected industry partners where all aspects relevant for robustness will be emphasized including positioning the sensor, sampling and considering environmental factors (such as temperature, light etc.). Building on this, further work will focus on the investigation and development of appropriate approaches for modelling, calibration and maintenance.

Finally, performance of models will be assessed over time in-line at industry partners with the objective of improving the understanding of industrial processes both in terms of distributions and dynamics, but also in terms of relationships between processing stages.



Photo/cc: Jens Petter Wold, Nofima

The implemented sensors will be used to explore and map variations in food processes over time.

Pillar 4 Utilization of large-scale quality assessments

In this Pillar, we will develop data-driven solutions for process, product, and value chain optimisation. The solutions will be based on extensive food quality measurements, combined with other relevant data sources from farm, industry, and consumer.

There is a strong link between health and welfare of animals, fish and plants, and the resulting food quality. Decision support for farmers involves for instance optimised feeding, care, and time of harvest, as well as early detection of health and welfare threats. We will combine food quality measurements with data on environmental and husbandry factors to investigate how they affect quality and health. This knowledge can be used in either long-term production planning or in real-time decision support.

In/on/at-line food quality measurements can be used to monitor, optimise, and control production processes. We will develop solutions that transform the multitude of measured and registered data in a production line into meaningful information needed to adjust and stabilize the production or tailor-make specific end-product quality categories. As in farming, the information can be used in either long-term improvement work or real-time monitoring and optimisation.

Well-documented and tailored food products can contribute to increased consumer satisfaction and reduce food waste. We will investigate consumers' attitudes and willingness to pay for different quality categories, and from that develop communication and marketing strategies to target different consumer profiles. We will investigate how the growing focus on food waste may impact food choice with respect to product quality.

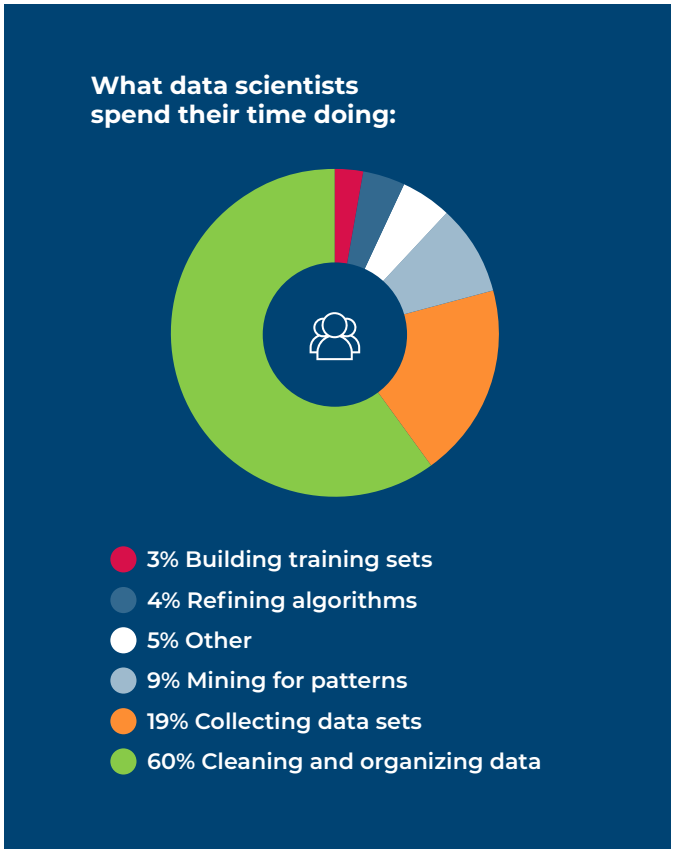
Pillar 4 is led by Senior Scientist Ingrid Måge at Nofima. Key partners include all food companies, Intelecy, CAMO, Idletechs, CGI, Prediktor, Maritech, IBM, NMBU and UPV.

COMBINE

Data preparation is a crucial and resource-demanding part of any data science project, especially when we need to combine data of different types and from different sources. Data preparation includes operations such as cleaning, synchronising, aggregating, transforming, structuring, and validating data.

In COMBINE, the research partners and analytics companies will perform a systematic review of typical data types and challenges in the food industry, along with available strategies and methods to solve these

What data scientists spend their time doing.



challenges. We will base the review on concrete cases from the DigiFoods food industry partners and available solutions from the analytics companies. The main aim of the project is to identify needs for further research and development in the data preparation pipeline.

MODEL

All data-driven solutions require some form of data modelling. In DigiFoods, the models will typically relate quality attributes to controllable and uncontrollable factors from farming or processing. We will develop methodology for two types of models: path modelling and real-time modelling.

Path models are intended to model causal relationships between sets of factors. These models extract quantitative information about causal effects, and thereby lead to increased insight that lay the foundation for improvement work and decision support systems. Such models need to be transparent and interpretable but will usually not be used for making predictions.

The second type of model is intended for real-time monitoring, control, or decision support. Such models need to provide precise, reliable, and robust predictions, often at high speed. They also need to detect and diagnose deviations from normality at an early stage and be formulated in such a way that they can be implemented in real time.

Two PhD students will be associated with the project, each addressing one of the modelling types. One or two industry cases will be selected for each of the two approaches in 2021, and possibly more the following years.

"These models extract quantitative information about causal effects, and thereby lead to increased insight that lay the foundation for improvement work and decision support systems."

Photo/cc: Chris Liverani, Unsplash

By combining data from different sources and locations in the value chain, we will enable efficient data analysis and lay the foundation for successful data science projects.

Photo/cc: Kristoffer Skarsgård, Saga Robotics

During a workshop at a farm in Kent (United Kingdom), Saga Robotics and University of Lincoln are testing autonomic navigation of robots. From left Pål From (Saga Robotics), PhD. Grzegorz Cielniak (University of Lincoln), Jaime Pulido Fentanes (Saga Robotics) og Michael Hutchinson (Saga Robotics).

(Image to the left) From left Lars Grimstad, Michael Hutchinson and Halvard Grimstad (all Saga Robotics) are making the last fine-tunings before testing autonomic navigation.

5. International collaboration

DigiFoods has established close collaboration with three excellent foreign research groups and three foreign high-tech technology providors who will be important for carrying out the planned research. They will take active part in the running projects and share supervision of PhD-students. Exchange of PhDs and post docs will be planned.

Foreign technology companies are also partners in DigiFoods, since they offer technology of interest to the centre and Norwegian food industry:

1. **University of Lincoln (ULin),** (UK), is represented in DigiFoods by Professors Simon Pearson and Gregorz Cielniak and their research group at Lincoln Institute of Agri-food Technology. They will contribute with expertise in autonomous and long-term navigation of agricultural robots, sensor and implement integration and data gathering, management and analysis. The university has a research farm with more than ten of Saga Robotics' Thorvald robots that can be used for extensive testing in a realistic environment. They will take active part in MOBILESENSE and ROBOSENSE.

2. **Ulm University (UUlm),** (Germany), is represented in DigiFoods by Professor Boris Mizaikoff, director of the Institute of Analytical and Bioanalytical Chemistry (IABC). UUlm has developed miniaturized mid-infrared sensing platforms based on thin-film semiconductor, oxide/nitride, and diamond waveguides that have already demonstrated their potential for analyzing e.g., secondary structure changes in proteins. UUlm will take part in the project IR and develop this platform further for in-line measurement of protein, lipid composition in foods and dairy and bioprocess control.

3. **The Polytechnic University of Valencia (UPV),** (Spain), is represented by Professor Alberto J. Ferrer-Riquelme, group leader of the Multivariate Statistical Engineering Group. The group is devoted to research, development and innovation activities in the area of multivariate statistical techniques for quality and productivity improvement and mega-database analysis. Professor Ferrer will participate in the MODEL project and provide joint supervision of PhD students and on data analysis and real-time process control.

4. **MarqMetrix,** (Seattle, USA), provides modern, easy to use Raman instruments for rapid material analysis and process measurements. They are represented by Brian Marquardt, world leading in development of process Raman systems and very interested in novel food applications based on Raman. He will contribute with knowledge and instrumentation in the project RAMAN.

5. **nanoplus Gmbh,** (Gerbrunn, Germany), is represented by Johannes Koeth. They will contribute by bringing in capabilities and related expertise in the field of Quantum cascade laser (QCL) and Interband cascade laser (ICL) technology. nanoplus' main task is to support in combining QCLs with waveguide technology developed by UUlm for in-line measurement of complex structures and composition in food samples in-line, such as fatty acid composition. This will be explored in the IR project.

6. **OptoPrecision GmbH,** (Bremen, Germany), represented by Markus Naegele, is a leading company in research, development, and production of high-quality optical sensing devices and will contribute by developing laser-driver and detection electronics in conjunction with the corresponding embedded software to realize a dedicated analyzer platform in Pillar 1 and the project IR.

PhD students at NMBU Robotics Group and Biospectroscopy collaborate on automated sampling.

Photo/cc: Håkon Sparre, NMBU

6. PhD recruitment and education

DigiFoods is planning to have a total of nine PhD fellowships and three post-doctoral fellowships associated with our research over the lifetime of the centre. The first PhD positions have been announced, and several candidates have been employed already.

These cover a large range of applications and instrumentations in the food industry. Their projects cover key areas from methodological and instrumental developments, optimal deployment and usage of sensors and analysis and understanding of sensor data.

At Nofima in Ås, Tiril Aurora Lintvedt, started her PhD work on in-line Raman spectroscopy, aiming for representative sampling and modelling of hetero-geneous foods. Christian Thorjussen will develop statistical path modelling approaches, aiming at better understanding of factors and mechanisms causing variation in food quality. Marco Cattaldo, enrolled at Universitat Politècnica de València, will develop statistical methods for process and product optimisation based on real-time measurements of food quality.

At Nofima and SINTEF Bijay Kafle will build and test an FTIR protype system for analysis of dried liquid samples, combining development of new applications with industrial testing of the FTIR prototype.

At Nofima in Tromsø post-doc Samuel Ortega Sarmiento will work on strategies for combining Magnetic Resonance Imaging and other reference methods for robust industrial applications of hyper-spectral imaging, improving physical modelling and light interactions.

At NMBU a PhD will develop a prototype hand-held IR instrument for food quality applications. Antonio Candea Leite will be employed as a post doctor to work on robot–sensor integration on autonomous mobile agricultural robots to gather data on yield estimates, diseases, ripeness, etc. and develop algorithms for robotic arm controlled near-infrared sensors in food production lines.

This part is led by Kristian Hovde Liland. A connection to the master programs in data science at NMBU has been established by offering relevant master thesis topics for students finishing their master education in 2022. The available projects include machine learning and calibration transfer for hyperspectral data and analysis of production data from food industry and aquaculture. When the projects of DigiFoods have all started, potential for further relevant master thesis topics, for students finishing in 2023 and beyond, is high.

	Location	Candidate	Funding	Project	2020	2021	2022	2023	2024
PhD-students	Nofima	Tiril Aurora Lintvedt	Nofima	RAMAN					
	Nofima	Christian Thorjussen	Nofima	MODEL					
	Nofima/UPV	Marco Cattaldo	RCN	MODEL					
	Nofima/SINTEF	Bijay Kafle	RCN	FTIR					
	NMBU	NN	RCN	IR					
Post-docs	Nofima	Samuel Ortega Sarmiento	Nofima	HYPERSPEC					
	NMBU	Antonio Candea Leite	RCN	MOBILESENSE					

Getting down to the nitty-gritty of food quality

by Marion O´Farrell, Sintef and Nils Kristian Afseth, Nofima

Whether you are making yoghurt, meat products or fish oil, a food producer must know that the product has the quality it should have and that the label correctly describes the product.

Some food and feed producers make measurements using near-infrared light – light in the frequency spectrum just above what is visible to us humans – to measure the total fat or protein content of the products. This is how a sausage maker can say that a hotdog has 18% fat, or minced meat can be sold as either 5% or 14% fat. These measurements can even be integrated into the process line to control or monitor the process in real time.

However, in some instances this information is simply not enough. You may need to know, not only the fat content, but the fatty acid profile; not only the total amount of protein, but the length and composition of the protein chains. In the dairy industry, laboratory based FTIR systems are widely used to determine major components such as fat, protein, lactose, and to some extent other components such as urea, free fatty acids and the content of some individual fatty acids. It has also been shown, for example, that the fatty acid concentration in milk will fluctuate slightly from day to day for an individual cow. It is known that being able to measure these lactation fluctuations regularly can enable biological modelling and reasonably tailored healthcare approaches for individual cows, which in turn could lead to greater productivity.

The laboratory based FTIR systems used in the dairy industry are all based on measurements performed directly in the milk. In the last six years, Nofima, SINTEF and Prediktor have been collaborating on liquid analysis research that aims to progress beyond current in-line FTIR systems that require complex pump and tubing systems for measuring small liquid volumes. Our approach is based on quickly drying the liquid sample before the analysis, so that the liquid is reduced to a dry film. In this way, the negative effect of water, a very efficient absorber of infrared light, is eliminated from the analysis. In addition, the components of interest are concentrated so that their chemical information is more visible. Based on our findings so far, we believe three important elements need to be addressed to advance in-line FTIR of liquid processes further: 1) capitalising on more readily available compact and cost-efficient FTIR components 2) achieve automatic and repeatable in-line preparation of dry films from liquid samples 3) long-term trials to get a better understanding of the natural biological variation in the samples.

In general, FTIR instrumentation is expensive, complicated, and best suited for use in laboratories.

“The laboratory based FTIR systems used in the dairy industry are all based on measurements performed directly in the milk.”

However, FTIR instruments often provide highly resolved data, meaning they often generate more data than required for sufficient accuracy. This can give lead the way for simplifying the instruments, for example by limiting the number of wavelengths, or using cheaper detectors, or more compact components. For example, SINTEF developed a lower-cost FTIR solution that worked without the expensive laser and built a prototype that can be adapted to the product line of the individual manufacturer. This was tested, with Nofima and Prediktor, on relevant industrial samples from bioprocessing of by-products where enzymes are used to recover proteins from by-products. The approach was successfully demonstrated at-line for monitoring the hydrolysis process at Biomega, a bioprocessing plant that has industrialised enzymatic protein hydrolysis of salmon by-products. Since this research, two important things have happened; there has been a rapid development in the field of miniaturized FTIR instruments (μFTIR), which are smaller and cheaper than traditional FTIR instruments, and there has been growth in the development of standard FTIR instrumentation with smaller footprints and lower weight (less than 2 kg), which could be compatible for use on the farm or integrating into process lines.

• Photo/cc: TINE

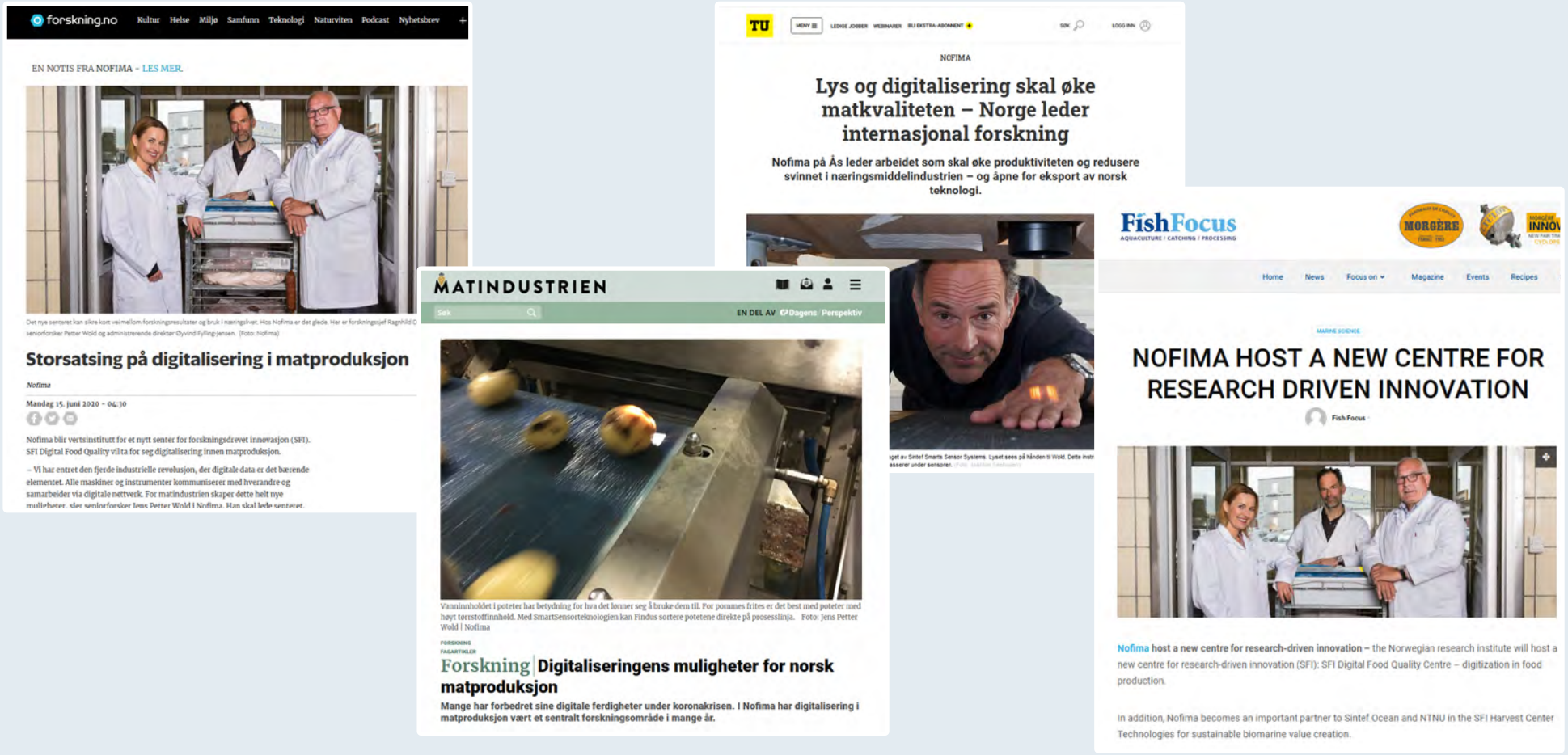
FTIR is a potential tool for monitoring of raw milk quality variations in dairy industry.

It is, therefore, excellent timing that DigiFoods has started. Two of the projects in the centre focus on the industrial potential of more complex food measurements that require measurement in the mid infrared range. One of the projects will progress from the research described above, where a compact FTIR system will be developed based on state-of-the-art components and will be adapted so it can be brought close to the process line in industry, enabling a PhD student to do industrial research that is relevant to industry. SINTEF will take responsibility for developing the instrumentation and ensuring good robust measurements. Nofima will work closely with the PhD student on using existing, lab-based FTIR instrumentation and developing methodologies for progressing to at-line measurements on the compact instrument. An important aspect of the FTIR project is developing a suitable sample preparation method that can be conducted at-line, and eventually achieving the goal of in-line measurements. The automated sampling research will be done in collaboration with robotics experts at the Norwegian University of Life Sciences (NMBU).

The second project, led by the BioSpec group at NMBU, is closely connect to the FTIR project and will focus on using novel mid infrared (MIR) light emitting diode (LED) sources that are being developed in two on-going EU projects under the ICT photonics programme. The goal is to investigate developing prototypes based on these components that are simpler, can potentially be low-cost, even handheld, and test them on selected applications. For these analyses, measurements in both liquid and dried state are possible. The overlap between these two projects is very interesting, where the compact FTIR prototype will be compared with the simpler handheld IR prototype for the complex liquid measurement applications.

7. Communication and dissemination

Several relevant trade magazines acknowledged the grant of SFI DigiFoods



forskning.no

EN NOTIS FRA NOFIMA – LES MER.

Storsatsing på digitalisering i matproduksjon

Nofima

Mandag 15. juni 2020 – 04:30

Nofima blir vertsinstitutt for et nytt senter for forskningsdrevet innovasjon (SFI). SFI Digital Food Quality vil ta for seg digitalisering innen matproduksjon.

– Vi har entret den fjerde industrielle revolusjon, der digitale data er det bærende elementet. Alle maskiner og instrumenter kommuniserer med hverandre og samarbeider via digitale nettverk. For matindustrien skaper dette helt nye muligheter, sier seniorforsker Jens Petter Wold i Nofima. Han skal lede senteret.

TU

NOFIMA

Lys og digitalisering skal øke matkvaliteten – Norge leder internasjonal forskning

Nofima på Ås leder arbeidet som skal øke produktiviteten og redusere svinnet i næringsmiddelindustrien – og åpne for eksport av norsk teknologi.

MATINDUSTRIEN

EN DEL AV Dagens Perspektiv

Vanninnholdet i poteter har betydning for hva det lønner seg å bruke dem til. For pommes frites er det best med poteter med høyt tørrstoffinnhold. Med SmartSensorteknologien kan Findus sortere potetene direkte på prosesslinja. Foto: Jens Petter Wold i Nofima

Forskning | **Digitaliseringens muligheter for norsk matproduksjon**

Mange har forbedret sine digitale ferdigheter under koronakrisen. I Nofima har digitalisering i matproduksjon vært et sentralt forskningsområde i mange år.

FishFocus

AQUACULTURE / CATCHING / PROCESSING

Home News Focus on Magazine Events Recipes

NOFIMA HOST A NEW CENTRE FOR RESEARCH DRIVEN INNOVATION

Fish Focus

Nofima host a new centre for research-driven innovation – the Norwegian research institute will host a new centre for research-driven innovation (SFI): SFI Digital Food Quality Centre – digitization in food production.

In addition, Nofima becomes an important partner to Sintef Ocean and NTNU in the SFI Harvest Center Technologies for sustainable biomarine value creation.

In DigiFoods the purpose of the communication is to present inventions and know-how from DigiFoods research as well as network development and knowledge exchange.

Our communication principles:

Proactive

Our communication will be active and targeted, to make sure that our research results reach our target groups.

Open

We will be open about how and why we conduct our research.

Honest

We will be honest and accountable in our communication.

Our priority target groups:

Industry

Food and bioindustry, technology companies

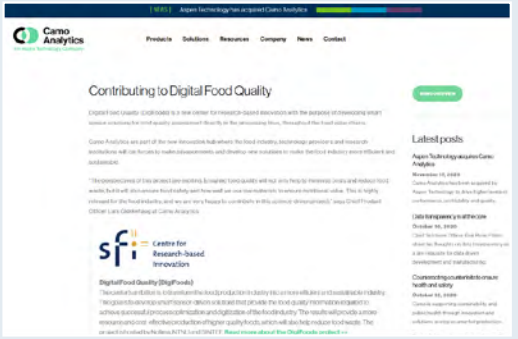
Scientific community

Scientist and students

Public

The Public, including funding bodies and policymakers.

The official opening of the center was in Dec 2020. The majority of the dissemination activities in 2020 are linked to the grant in June. In addition, some of our industrial partners have acknowledged and promoted their participation.



The devil is in the details

Wenche Aale Hægermark, Nofima

"It was my interest in quantum physics that led to my fascination with optics and spectroscopic measurements," says Tiril Aurora Lintvedt.

She is now a research fellow at DigiFoods and investigating how Raman spectroscopy can be used in the food industry for acquiring detailed, accurate measurements of the structure and quality of raw materials. In addition to using her knowledge of physics for calculating how to obtain information from the light spectrum of raw materials, she is constantly learning about food chemistry.

Food quality control throughout the value chain

There are several different ways of undertaking spectroscopic measurements suitable for various raw materials and measurements. At DigiFoods, several of these methods will be used for developing real-time measurements on a large scale. The aim is to enable food producers to control raw materials and food quality, all the way from the ocean, soil or cowshed - to the table. Raman spectroscopy is eminently suitable for undertaking highly detailed molecular measurements. Thus, it is possible to measure not just the distribution of fat, protein and water in raw materials, but also fat and protein types and quantities.

"Technological developments are on our side, enabling us to be increasingly faster and more precise. Raman spectroscopy initially consisted of one focused laser that measured a 1 mm spot on a sample. Now there are Raman probes that can measure 6 mm spots, and more importantly, we can scan many spots on a sample, thus making measurements more representative of a larger area," explains Tiril.

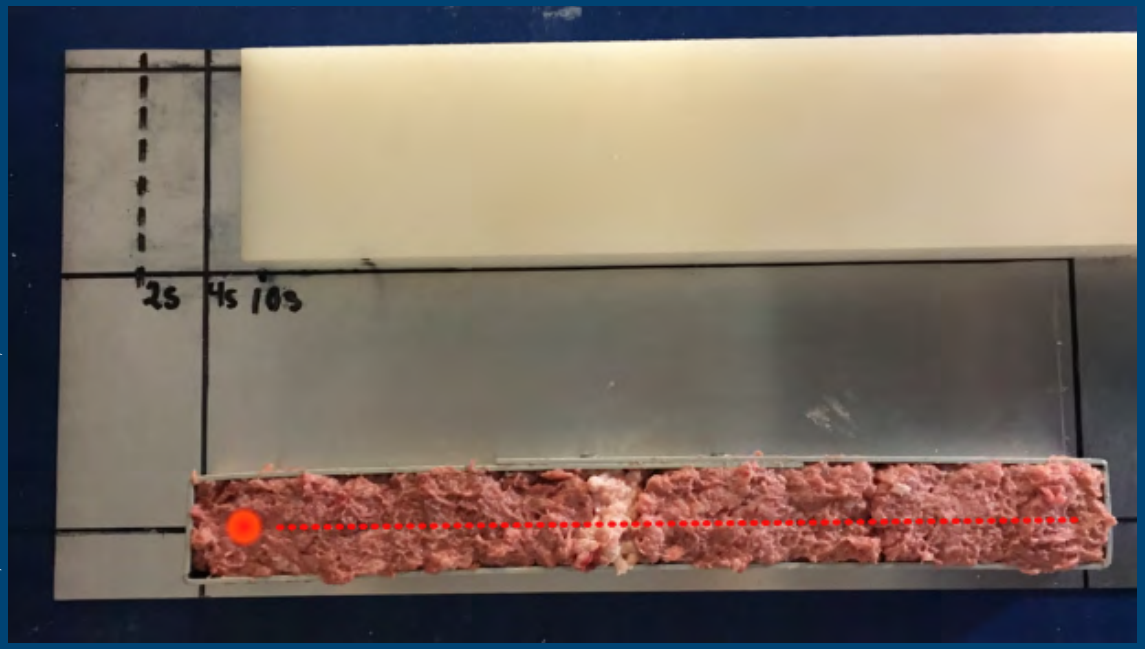
Supervisor and head of the DigiFoods Centre Jens Petter Wold agrees. *"Cheaper, better Raman technology means more applications. It was previously used in industries with expensive raw materials, e.g. pharmaceuticals. We are now investigating how Raman measurements of food raw materials can help to increase raw material utilisation, ensure uniform product quality or develop differentiated products."*

Measures fatty acids composition in salmon and bone in chicken by-products

One of the quality targets for farmed salmon is its marine fatty acid content: the higher the percentage of omega-3 fatty acids, the better. Chicken by-products should contain as little bone as possible. Tiril is investigating how Raman can be used for measuring the fatty acid composition of salmon and bone residue in chicken by-products.

A minced chicken sample is being prepared in an elongated sample container, in which it will be sent down a conveyor belt at different speeds.

Photo/cc: Tiril Aurora Lintvedt, Nofima



• Photo/cc: Tiril Aurora Lintvedt, Nofima

All of the 30 centimetres of sample will be measured when they pass the Raman probe on the belt.

"DigiFoods is aiming to develop robots with inbuilt smart optical sensors."

She is experimenting to see how fast samples on the conveyor belt can move to ensure that Raman measurements can capture the necessary details in light spectra and provide exact predictions. The results are promising.

Many speed trials have been conducted. At times the conveyor belt in Nofima's meat hall has been running constantly. Sometimes cups of minced salmon have been moving along the conveyor while the Raman probe has been scanning samples and capturing enough details for measuring fatty acid composition. Sometimes the aim has been to investigate how fast chicken by-products can be conveyed while still undertaking suitably precise measurements.

"So far I have mainly tested minced raw materials and have used the results to calibrate the instruments so that they measure exactly what we want them to measure, and at the speed we want them to measure. It is harder to measure whole pieces or fillets than mixtures containing an even distribution of fat or bone," says Tiril.

Functional measurements for the industry

She will now start testing to see what is needed to ensure that the measurements work just as well when whole salmon fillets are transported on the conveyor belt. The aim is to develop strategies that will enable measurements to be made at the same speed as that which applies to fillets moving along the processing line. The measurements must also be equally precise for each fillet, even when they follow each other closely.

Another challenge Tiril is starting to solve is to find the best positions for taking measurements on salmon fillets in order to obtain the information required.

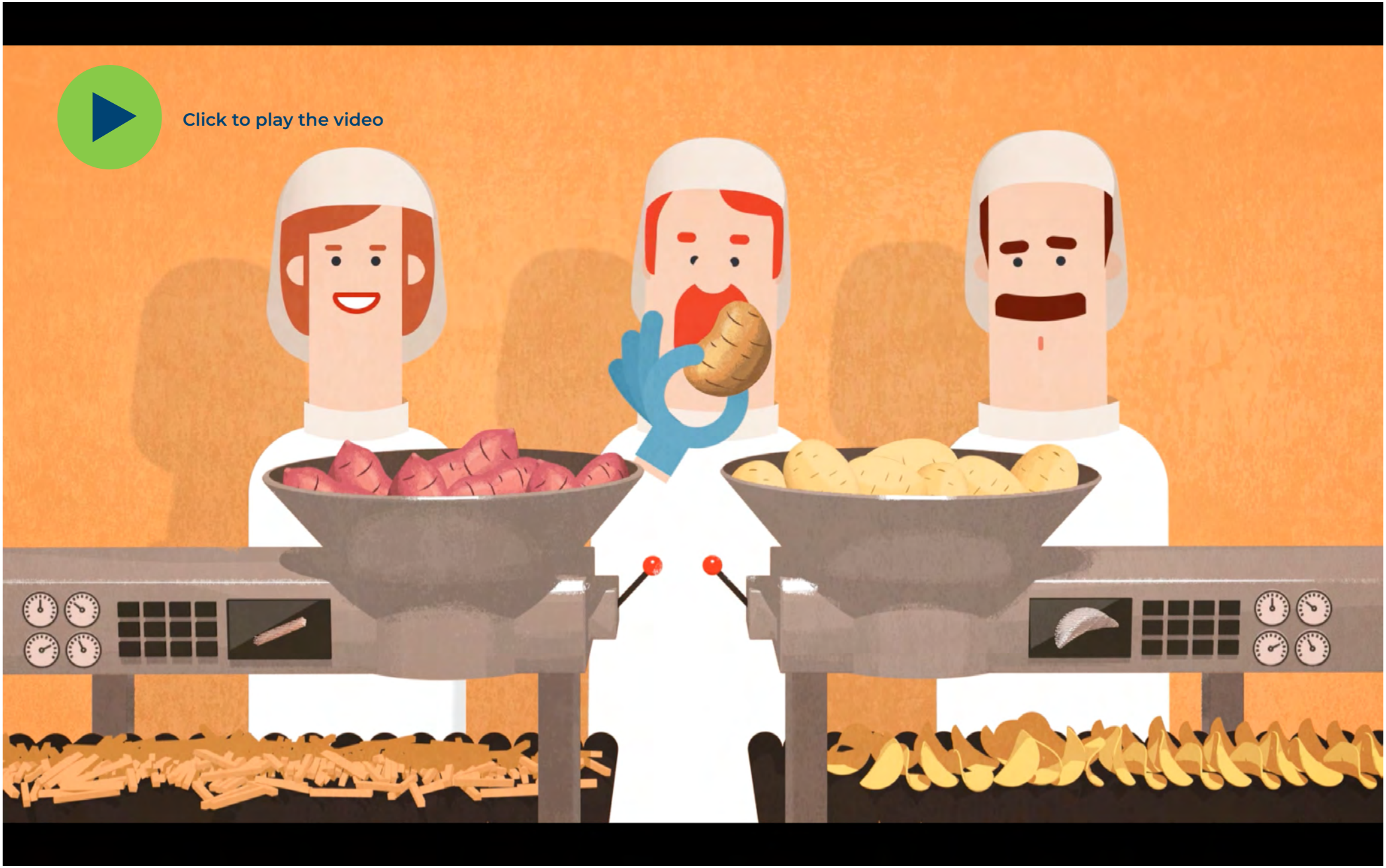
"Our research to date suggests that the belly provides the best information, simply because there is more fat there. But we need to undertake more measurements and analyses before we know exactly how we get the most representative measurements," she says.

More responsible production

DigiFoods is aiming to develop robots with inbuilt smart optical sensors. It should be possible to make these sensors measure the most suitable spots, at the right speed and frequency – and provide answers about exactly what needs to be identified.

Tiril is keen to be part of the solution and help to achieve responsible production.

"If manufacturers are to succeed, they need correct, understandable information that they know how to use. We need to make the system sustainable. Our aim is optimal usage of all raw materials. I think it's right to focus on the industry. They already have many automatic processes, so why not make them smarter," she asks rhetorically.


Click to play the video

Smart sensors – sustainable foods

DigiFoods

SFI Digital Food Quality (short named DigiFoods) is a centre for research-based innovation (SFI) with the purpose of developing smart sensor solutions for food quality assessment directly in the processing lines, throughout the food value chains.

digifoods.no

sfi Senter for forskningsdrevet innovasjon

Norges forskningsråd