DigiFoods

SFI Digital Food Quality

ANNUAL REPORT 2025

• **Cover** Photo/cc: Jon Tschudi SINTEF

SenseInside demonstration for the clip fish industry in Ålesund, Norway.

• Photo/cc: Rolf Skjong Fuglefjellet, FFHF

Determination of water content in dried salted cod with the newly developed SenseInside NIR instrument. Read more abot SenseInside on page 15 in this report.

Colophon

Multiple authors (2026).

Annual Report 2025.

SFI Digital Food Quality – DigiFoods.

Ås: Nofima, eds.

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Contents

1. Overall progress and summary for 2025

DigiFoods is a Center for Research-based Innovation, funded by The Research Council of Norway (RCN) and the partners. DigiFoods is developing smart sensors for effective food quality assessment directly in the processing lines and in field.

The intention is that massive assessment and digitalisation of essential food quality parameters will be used for optimisation of processes and value chains and make the food industry more efficient and sustainable. This research is in the very exiting intersection of food science, sensor technology, process control, robotics, and data analysis, and gives rich opportunities for innovation at different levels.

DigiFoods started at the end of 2020 and is now, after five years, more than halfway through. Most activities are progressing well, and industry partners are active in the work. The centre is organised in four main activities (pillars) including

1. sensor development,
2. integration of sensors and robotics,
3. in-line implementation and testing, and
4. utilisation of large-scale sensor data from foods.

This organisation works as intended: New sensors developed in one pillar are incorporated in the research in other pillars. Novel in-line methods developed earlier years, are adapted, and used to collect large-scale quality data for process understanding and improvement. This kind of progress is motivating and illustrates the added value of being a center rather than several stand-alone projects. It gives us the opportunity to think and act long-term and interdisciplinary.

The annual meeting with all partners was held in spectacular Svolvær in May, including a trip to Lerøy Seafoods in Stamsund where we got an introduction to fish cake production and could watch an experimental set-up for continuous core temperature monitoring with NIR spectroscopy. The meeting became a very good event for socialising, sharing results, ideas and planning further work. It was also a good opportunity to share and discuss the results from the mid-term evaluation of DigiFoods. It was very positive review of the work we are doing and how we are organised, especially the involvement of the companies. This is highly motivating feedback as we embark on the final years of the centre.

During 2025 we conducted small and large measurement campaigns in the process lines. Some lasted a day, others took weeks. We thank the companies for opening the doors, providing technology, and engaging in this kind of work. This sort of activity is the core of DigiFoods, where we can learn about the products and processes, consider the challenges, develop and test the sensors, gather the partners to discuss the results, and together see potential innovation ahead.

Our work was structured into twelve research projects, spanning topics from sensor and application development to robotics, process analysis and consumer demands. We have experienced scientific highlights, but also some disappointments – that is how research is!

In many cases we work with research that is very close to becoming real innovation

Photo/cc: Stine Thøring Juul, Nofima

The DigiFoods consortium gathered for the 2025 Annual meeting in Svolvær.

In many cases we work with research that is very close to becoming real innovation.

Fourier-transform infrared spectroscopy (FTIR) can be used to measure protein composition. We have demonstrated that FTIR can detect variations in peptide size and collagen content in industrial peptide mixtures from ensymatic hydrolysis and shown that industrial measurements can improve understanding and control of such processes.
We are developing miniaturised IR technology based on novel LEDs (light-emitting diodes) and semiconductor lasers. This enables small, handheld, and affordable sensors that can measure various chemical properties of food throughout the value chain. Prototypes of both technologies have been developed and are currently being tested for protein measurements.

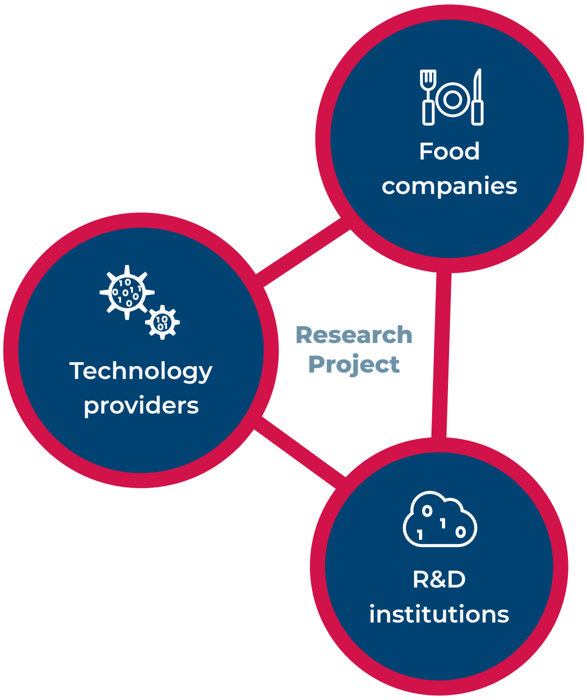
We have demonstrated that Raman is suitable for determination of various food quality attributes of heterogenous foods directly in industrial processes. We have also benchmarked Raman against NIR spectroscopy with respect to robustness regarding variation in sample structure, as well as cost of calibration and maintenance. In 2025 we compared Raman and NIR spectroscopy side by side for in-line monitoring of salmon by-products. It was challenging! Hyperspectral camera technology has been developed for industrial measurement of fat, pigment, blood and melanin spots in salmon fillets, and the technology was put into commercial use in 2024. We have recently seen that it is possible to detect and quantify remaining blood in whole fish – through the skin. This technology is interesting for several different quality measurements on fish and meat, and we have also studied opportunities within sweetness measurements in strawberries and tomatoes.

We have developed a new NIR sensor for non-contact sub-surface measurements – *SenseInside*. It can be used for sugar measurement in strawberries in the field and in tomatoes on a packing line. The NIR sensor has demonstrated potential for in-line assessment of core temperature in fish cakes, meat content in king crabs, and moisture in salted cod and clipfish. We are working to commercialise this technology.

An important activity in the center is to conduct in-line measurements in industrial processes, and we have worked on the following cases: Dry matter in potatoes and cheese, sugar in tomatoes, core temperature in fish cakes, fat content in sausages and beef loins, fat, protein and bone in poultry and salmon by-products, as well as quality attributes in salmon fillets. All these methods are novel and can significantly contribute to process improvement. The food companies learn about the process variations, leading to improvements in some processes, with the goal of reducing waste and achieving consistent final quality. In 2025 we collected in-line spectroscopic and other process data from TINE, Norilia, HOFF and Lerøy. This has given an increased understanding of the processes and quality variations, and for TINE, the strategy has produced lasting innovations that contribute to increased profitability and better utilisation of incoming milk.

Within robotics we have been further developing and testing a system for automatic Raman sensing of salmon fillets. We have also developed automatic measurement of sweetness in strawberries and tomatoes by using agricultural robots equipped with our newly developed NIR sensor.

Our students are well integrated in the different projects and contribute to many of the centre results and dissemination



DigiFoods innovation model: Each research task assigns 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.

In 2025 we had nine PhDs/post-docs connected to DigiFoods. We also recruited one master student who contributed to our work. Our students are well integrated in the different projects and contribute to many of the centre results and dissemination activities.

In this annual report we present the main work and results achieved in 2025. Interesting highlights from the research are presented in more depth. Our work on comparing Raman and NIR in the food industry is novel and you can read about the practical challenges encountered during the work at Biomega. The work on IR spectroscopy is promising, and we can now outline potential directions for commercialisation. Innovation is a core driver in DigiFoods, but what does it take to succeed with innovation in deep tech? We asked Associate professor Ellen Altenborg. We hope that you will enjoy the annual report 2025.

Jens Petter Wold
Centre Director, SFI DigiFoods

Article

A realist with an eye on deep tech

by Wenche Aale Hægermark, Nofima

Ellen Altenborg sits on the board of DigiFoods and works as a scientist on why deep tech innovation succeeds – or fails. Her background from Telenor, the agricultural robot Thorvald and several startup environments has given her insight into what it takes to move scientific breakthroughs from the lab to the market.

Photo/cc: Handelshøyskolen BI

Ellen Altenborg

The original plan was to become an academic. In the 1990s, Ellen Altenborg completed a PhD in strategy at the Norwegian School of Economics with Telenor as topic. When Telenor then offered her a position in its newly established Group Strategy department, it was impossible to turn it down.

"This was just after Televerket became Telenor, when mobile phones and the internet were still new. The challenge was both cool and exciting. I told myself I would do this for a couple of years – and then go back to academia," Ellen Altenborg recalls.

It would be another 25 years before she actually returned to academia – because she discovered how much she enjoyed business. Throughout her career she has worked in technology companies, always close to new technology and its commercialisation.

At Telenor she worked with regulatory issues, stock exchange listings and mergers. In her last years there, she worked on new business areas, developing fintech solutions and new financial products.

"We actually built something very similar to Vipps long before DNB – but for Pakistan and other countries in South Asia," she says.

Discovery of deep tech

By coincidence, Ellen Altenborg met Pål From, the scientist behind the agricultural robot Thorvald and Saga Robotics. That encounter drew her into the startup environment at NMBU and led her to deep tech, which she defines as technology so complex that it requires a strong academic background to really understand.

She quickly realised that many of the solutions to global challenges are developed at universities – but often remain there. Finding ways to bring deep tech out of academia and into use is what drives her, also in her current role as Associate Professor at BI Norwegian Business School. At the core of her research lies a simple but demanding question: What does it take for deep tech knowledge from universities and research environments to be turned into commercial solutions – and how can we make that journey faster?

"It is an extremely demanding process to take deep technology – the science itself – run it through a commercialisation process and actually get it out into the world. This is not something that just rolls forward by itself. The processes are long, and the need for funding along the way is substantial. Many ventures fail, and you rarely hear much about them – you mostly hear about the few that succeed," Ellen explains.

Technology is not the same as a product

Her work with the Thorvald robot gave her a close-up view of how complex the journey from technology to product really is. Patience and a deep understanding of the technology are essential to grasp the real opportunities and limitations, and to

By narrowing the focus to the food industry, as DigiFoods has done, you remove a lot of complexity and enable companies to take concrete steps.

Ellen Altenborg, SFI DigiFoods

estimate how long development will take. The technology must be stable and reliable before you can enter into commercial contracts. Getting it to that point takes both time and funding.

"Technology and product are not the same – the differences are actually quite substantial. Take Thorvald as an example: the technology can be used for many things and solve a range of tasks. But you must identify the first application area that is accessible and create enough value for someone to invest time and money. That's what buys you the time you need to make the technology truly robust. The first product from Saga Robotics was area-based UV light treatment, offered as a service," she says.

Commercial thinking has to come in early

One of the key differences between a research project and a company is how people relate to the future. Customers expect a company to be there as a long-term supplier, and partners behave differently towards a business than towards a time-limited research project. The level of commitment is deeper and of a different nature.

Ellen Altenborg is clear that commercial thinking needs to come in much earlier than is often the case today.

"I have spent countless hours out on farms with Thorvald, just watching how it actually works in real life. We need more people who both understand the technology and have commercial instinct – people who are willing to put on the crampons or the blue overalls and be out where things happen, not just sit in an office. It takes time, and it requires focused effort and relationships with people who can help pull the project forward," she says.

Limited capital, strong cultural advantages

Bringing deep tech to market requires the ability to live with complexity across several disciplines – and it requires capital.

"Lack of capital is a real challenge in Norway, more so than in Sweden. But we also have some strong advantages. Norwegians are generally good at dealing with uncertainty and taking responsibility. Any development environment needs people who work independently and are willing to try things, and that is deeply rooted in Norwegian work culture. Things simply move faster when the boss is not controlling every detail," Ellen Altenborg says.

She also points out that Norwegian scientific environments are highly applied and practice-oriented. In her view, this gives Norway a strong starting point – and it is easier to improve the capital situation than to change the underlying culture.

Building competence for the future

DigiFoods is the first centre for research-based innovation (SFI) in which Ellen has been heavily involved.

"The concept is very strong, and the long-term perspective is crucial. By narrowing the focus to the food industry, as DigiFoods has done, you remove a lot of complexity and enable companies to take concrete steps – change processes, adjust how they work and build new relationships. That strengthens the industry. What I appreciate most, though, is the competence building: the PhDs that remain as a foundation. In DigiFoods, that means people who really understand fisheries, aquaculture and the wider food industry – all major sectors in Norway," she says.

She emphasizes that only the public sector can make such investments in long-term capacity building. The risk is simply too high for private capital, and the impact is difficult to measure in the short term.

Digifoods technology in the classroom

Ellen brings DigiFoods technology directly into her teaching. She uses the DigiFoods sensor concept SenseInside as a case for master's students in strategy and entrepreneurship. The students are tasked with developing a financial model for the sensor while learning to handle complexity in both technology and market. This gives them hands-on experience in understanding technological constraints, quantifying uncertainty and evaluating different market opportunities.

"It was important to choose a case based on a technologically complex product that they were not already familiar with. They need to learn how to approach and manage that complexity. This kind of experiential learning gives an understanding you simply cannot convey on paper," Ellen concludes.

• Photo/cc: Jon Are Berg Jacobsen, Nofima

Tiril Lintvedt working on Raman scanning of salmon fillets.

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 digitalisation 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.

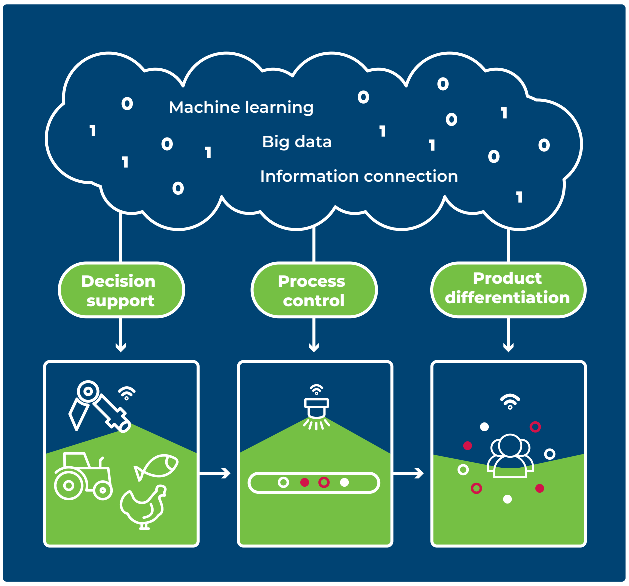
The **Primary objective** of DigiFoods is to develop digital solutions for food quality assessment as cutting-edge technological basis for optimal food value chains.

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, nine PhDs and three 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 strives to change food production by enabling optimization, control and differentiation based on measurements of food quality. The results 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.

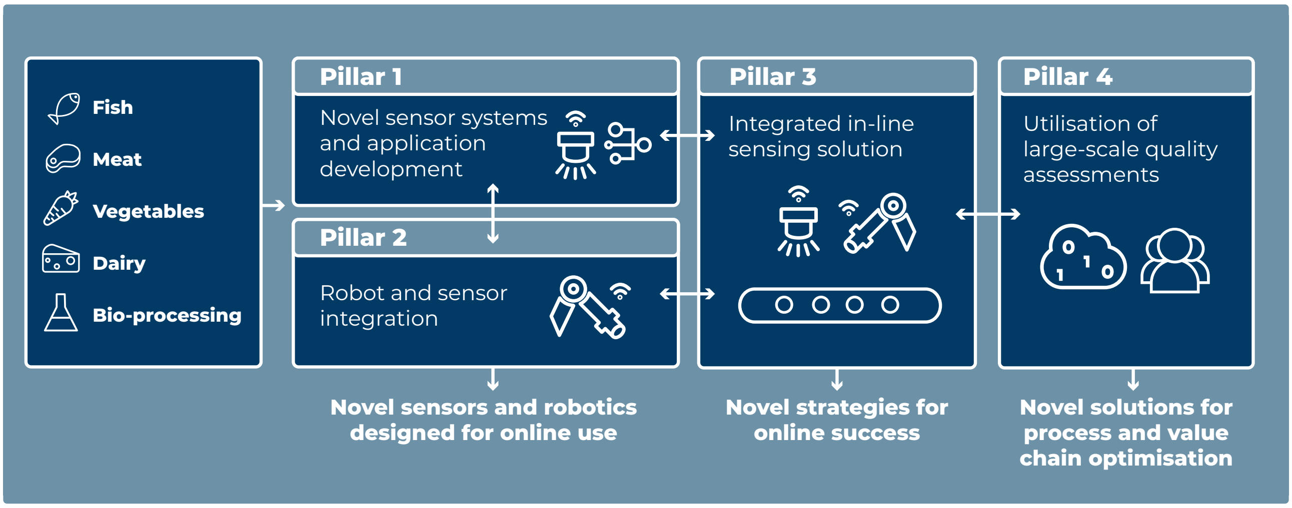
2. Research plan and strategy

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

The innovations in DigiFoods are accomplished by combining basic and applied research. A major difference from traditional research in this area lies in the scientific method; prototypes are being 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. The research activities are organised in four pillars, and involves value chains for fish, meat, vegetables, dairy and bio-processing. These pillars are not closed; most activities straddle two pillars or more and others have progressed from one pillar into another.

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

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



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

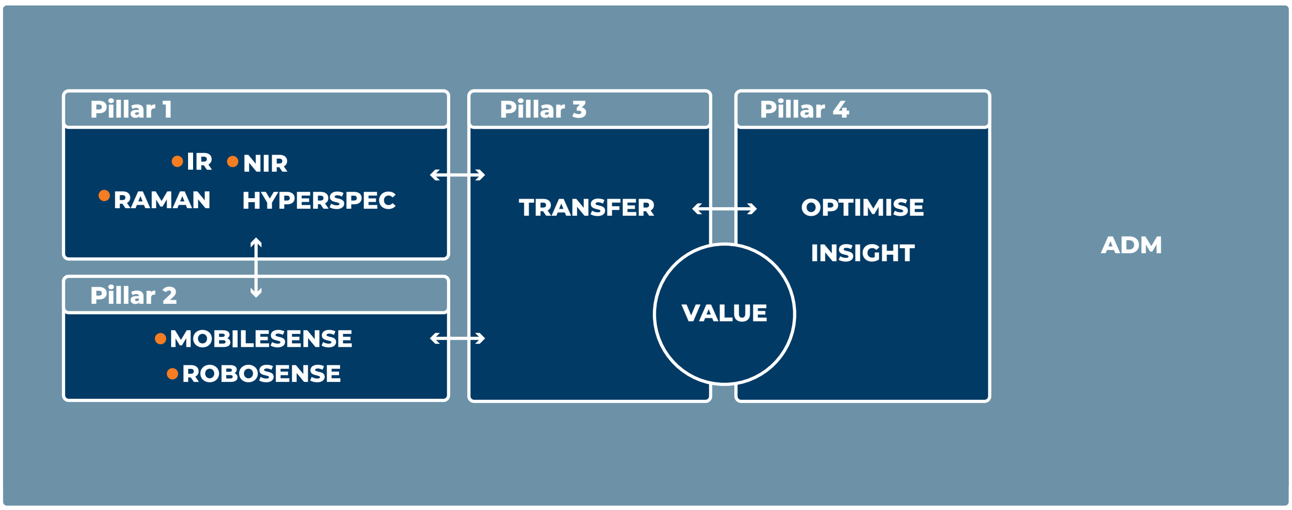
The research activities are organized in four pillars, and involves value chains for fish, meat, vegetables, dairy and bio-processing

All activities do 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 are considering business cases and innovation opportunities associated with the research.

To implement the research, we have divided the activities into research projects, twelve in 2025, reduced to ten in 2026. The projects address the outlined goals and envisioned innovations, targeting gaps in knowledge and technology.

All partners are involved in the planning of the projects, ensuring relevance, and securing in-kind contributions through active involvement in the ongoing work.

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



SFI projects allocated in research pillars according to the figure on the previous page.
● PhD / Post doc

Article

Research funding must deliver concrete impact for industry

by Wenche Aale Hægermark, Nofima

"Good applied science is about trust, openness and clear impact for the industry."

The words belong to Ståle Walderhaug, Chief Executive Officer of the Norwegian Seafood Research Fund (FHF). He sees SenseInside, which has grown out of DigiFoods, as a strong example of several leading expert groups coming together to tackle concrete challenges in the seafood sector.

SenseInside is both the instrument that scientists are now developing and the short name for the project *Industrial testing of a portable NIR instrument in the fisheries and aquaculture sectors*, which is financed by FHF. The ambition of the project is to test and further develop the instrument so that the solution can be utilised by the industry and contribute to better resource utilisation.

"We see ourselves as the R&D department for the fisheries and aquaculture industries," he says. For him, that means being transparent about the fact that FHF exists to serve the industry – and that both successes and failures need to be on the table. At the same time, trust in academic institutions has to remain rock solid.

Walderhaug holds a PhD in systems development and has more than 20 years' experience as a scientist and research manager at SINTEF Digital. At FHF, he considers it essential that both industry and scientific environments can trust the process and the results. Methods and findings must be verifiable. Research topics are guided by the needs of the industry, and the results must be openly available so that they benefit both the industry and society.

Why SenseInside fits FHF

When FHF evaluates projects, the starting point is to assemble the strongest possible teams around the most important challenges for the industry.

"We need people who understand biology and fish, working together with technologists and data specialists. SenseInside is a good example of this. It brings together raw material, calibration and data analysis expertise at Nofima with optical and sensor know-how at SINTEF Digital. That is exactly the kind of 'national team' we want to build," says Walderhaug.

FHF prioritises applied science that can reach industrial use within a reasonable time frame. It is therefore a clear advantage when a large part of the groundwork, such as method development, has already been carried out – ideally in a centre for research-based innovation such as DigiFoods. The fact that SenseInside builds on such a platform makes it easier to move into industrial piloting and scaling.

High innovation level and scalability

FHF does not expect all projects to be risk-free. On the contrary, a high level of innovation is desirable, as long as there is a realistic path towards practical use. In the case of SenseInside, it has been important that the technology is both novel and tailored to industrial processes.

Another key criterion is scalability. Instruments that can be produced in series, reuse components and be operated with accessible service and support are far more relevant for the industry than solutions that remain one-off prototypes. For FHF, it is not only the initial investment that matters, but also operating costs, maintenance, robustness and service levels over time.

More than a new sensor

SenseInside is more than a new measurement device. The solution can give food businesses better control of product quality, less waste and more precise utilisation of raw materials.

"The quality of Norwegian seafood has to be top tier. Internationally, Norwegian seafood is associated with high quality, and that reputation is important to maintain. Technology that allows us to monitor quality continuously helps us ensure that what we send out actually matches what we promise," Walderhaug says.

He also points out that instruments like this provide insight into how, for example, freezing, storage and processing affect quality.

Photo/cc: Marius Fiskum, FHF

Ståle Walderhaug

Photo/cc: Rolf Skjong/Fuglefjellet, FHF

FHF invited the clipfish industry to a demonstration of a tool for industrial testing of water content in clipfish at Brødrene Sperre on Ellingsøy in November 2025.

That knowledge underpins better utilisation of raw materials, more accurate pricing and more predictable production. Continuous quality measurements can act both as a day-to-day management tool and as a knowledge base for further development.

An impatient industry – and clear expectations

FHF expects scientifically solid work, orderly progress and clear communication in the projects it funds.

"We know the industry is impatient and would ideally like to see solutions in place already. The challenge is to balance that impatience with the demand for scientific quality. That cannot be compromised, but at the same time we expect scientists to give our projects high priority," Walderhaug notes.

For solutions like SenseInside to move from pilot to industry standard, he believes close cooperation is required over time between scientific environments, companies and funding bodies. From FHFs perspective, success is achieved when companies start asking for the solutions themselves.

"We place a lot of emphasis on communication, and we can help organise demonstrations and meeting arenas where more stakeholders are brought in. Together we can make sure that robust science does not end up in a drawer, but actually makes a difference in aquaculture and fisheries," Walderhaug concludes.

Facts about SenseInside

Project name: Industrial testing of a portable near-infrared (NIR) instrument in the fisheries and aquaculture industry (SenseInside).

Background: SenseInside is an innovation project spun out from the SFI DigiFoods centre to verify the commercialisation potential of an early miniaturised NIR prototype developed in DigiFoods.

Main objective: To conduct industrial evaluation of the new NIR instrument in the fisheries and aquaculture industry in order to contribute to commercialisation.

Funders: FHF – Norwegian Seafood Research Fund

Project period: 2025–2026
Research partners: Nofima, SINTEF Digital.

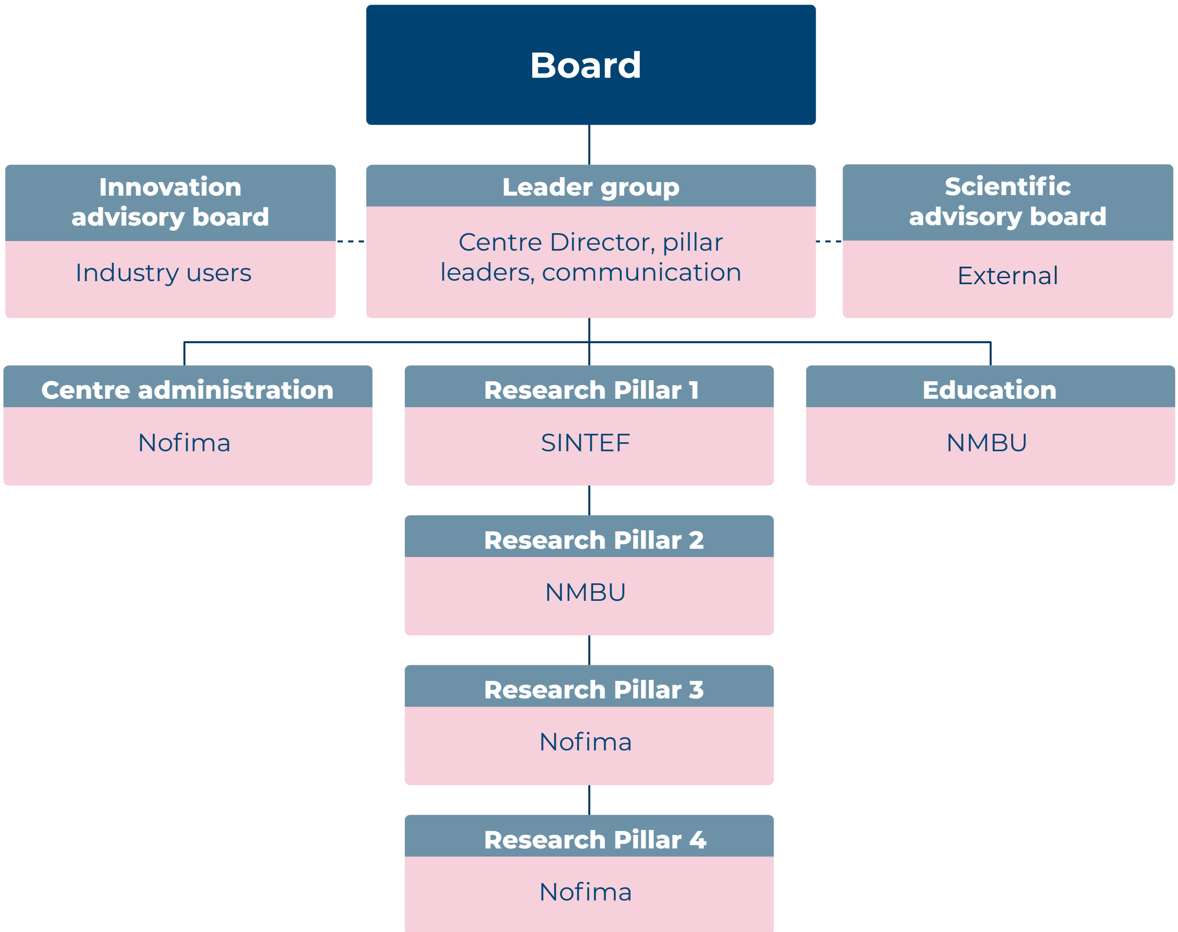
Industry partners:
Lerøy Norway Seafoods AS, Kjøllefjord (king crab) and Stamsund (fish mince), Brødrene Sperre and Nils Sperre, Ålesund (clipfish, mackerel, herring and fish mince), Sufi AS and Myre Fiskemottak AS, Lofoten (stockfish), Aquagen, Ås (salmon) and Hitramat, Hitra (brown crab).

3. Organisation

Organizational structure, and cooperation between the centre's partners

DigiFoods has a decentralised organisational structure. It's headquartered at Nofima, Campus Ås. The food industry is by nature decentralised, and the technology companies are also located around Norway. The organisation is shown in the figure below.

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 2025, the Board met for two physical meetings, one following the Annual meeting in May and one in November. The Board consists of the following elected members (see next page).



Chair of the DigiFoods Board

Heidi Alvestrand,
Norilia

Board Member

Jørgen Kvinge,
Lerøy Norway Seafoods

Board Member

Silje Ottestad,
Maritech

Board Member

Ellen E. Altenborg,
BI (representing
Saga Robotics)

Board Member

Mats Carlin,
SINTEF Digital

Board Member

Ingunn Burud,
NMBU

Board Member and representing the host institution

Eva Veiseth-Kent,
Nofima

The DigiFoods Board.

In addition, Mona Gravningen Rygh, the contact person for DigiFoods at the Research Council of Norway, has an observer status 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 Utilisation 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.

Photo/cc: Reidun Lilleholt Kraugerud, Nofima

The DigiFoods leadergroup, from left: Weria Khaksar, Marion O'Farrell, Ingrid Måge, Jens Petter Wold, Wenche Aale Hægermark, Anne Risbråthe, Stine Thøring Juul-Dam, Nils Kristian Afseth, Kristian Hovde Liland.

The leader group consists of:

- Jens Petter Wold (Nofima) – Center Director, overall scientific and administrative leader
- Marion O'Farrell (SINTEF Digital) – Scientific Manager of Pillar 1
- Weria Khaksar (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 Scientific Advisory Board (SAB) for DigiFoods, consists of researchers with competencies in the fields of research in the centre. An important task for the SAB is to review results and research plans and give advice on research methodology 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

Photo/cc: Marion O'Farrell, SINTEF

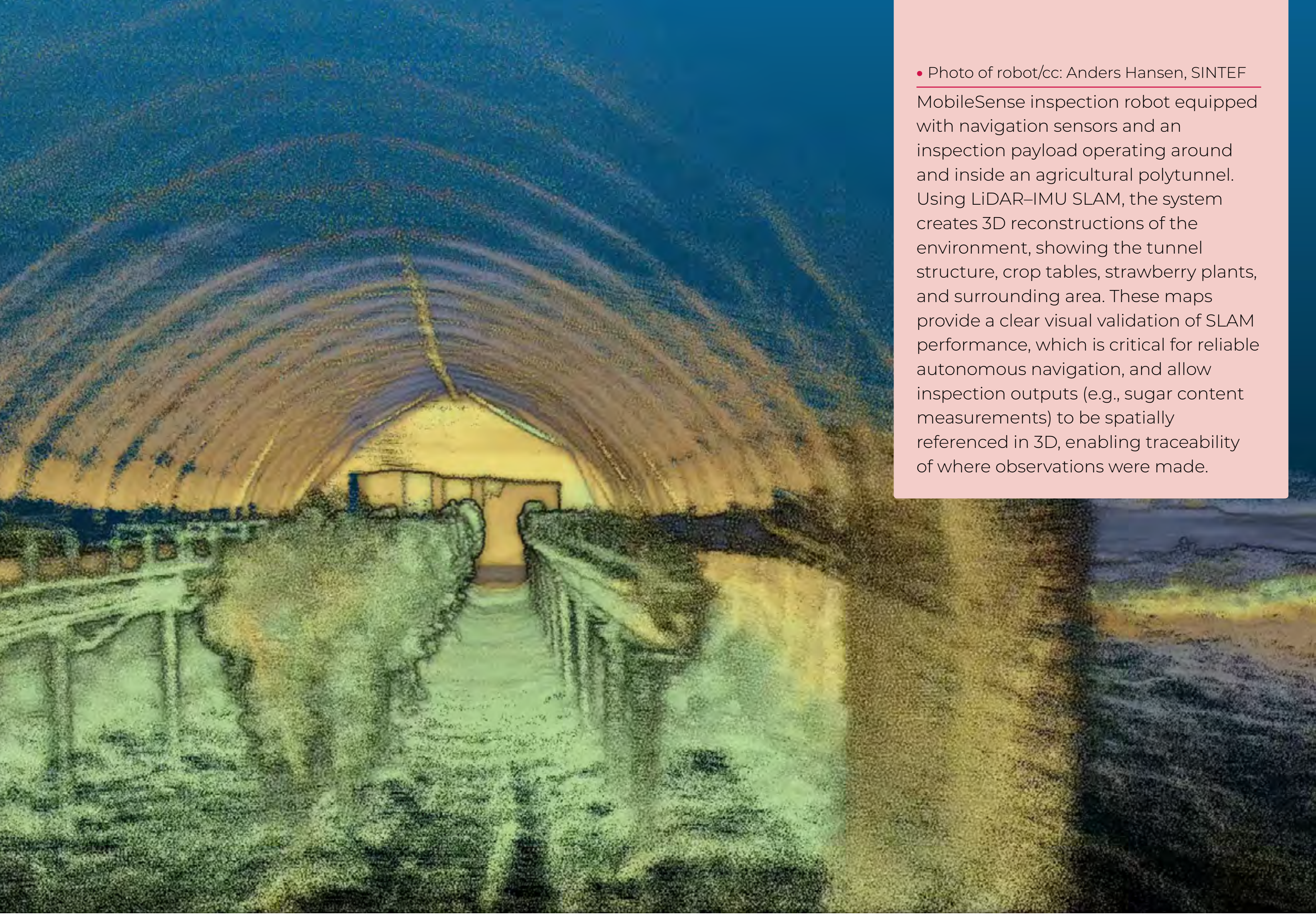
Our Scientific Advisory Board gathered for a two-day review of the research in DigiFoods. From left: Onno de Noord, Bjarne Kjær Ersbøll, Søren Balling Engelsen and Ole Alvseike. Centre Director Jens Petter Wold to the right.

We do also have an Innovation Advisory Board consisting of five people from the user-partners. IAB has monthly meetings with the different project leaders to discuss innovation potential and strategies based on the ongoing research. Members of the IAB were in 2025:

- Silje Ottestad, Maritech
- Piotr Chylenski, Norilia
- Per Berg, Nortura
- Roy Martin Hansen, Lerøy Norway Seafoods
- Ellen Altenborg, BI (representing Saga Robotics)

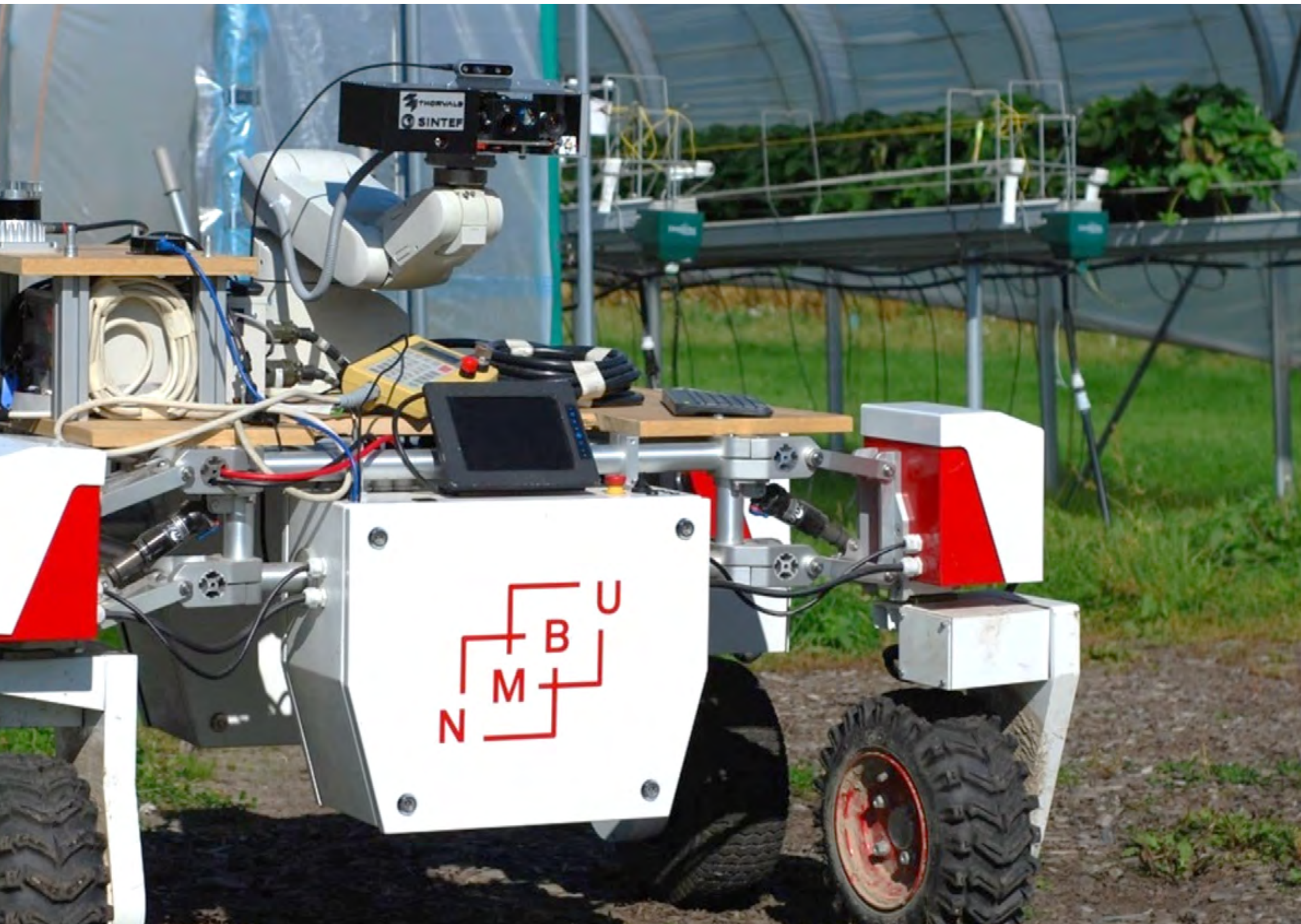
Frequent meetings are organised at Board level (each six months), Centre level (annual meetings), leader group (every third week), with IAB (once a month) and thematic or project level (as required). DigiFoods is also sharing news an centre updates on Linkedin.

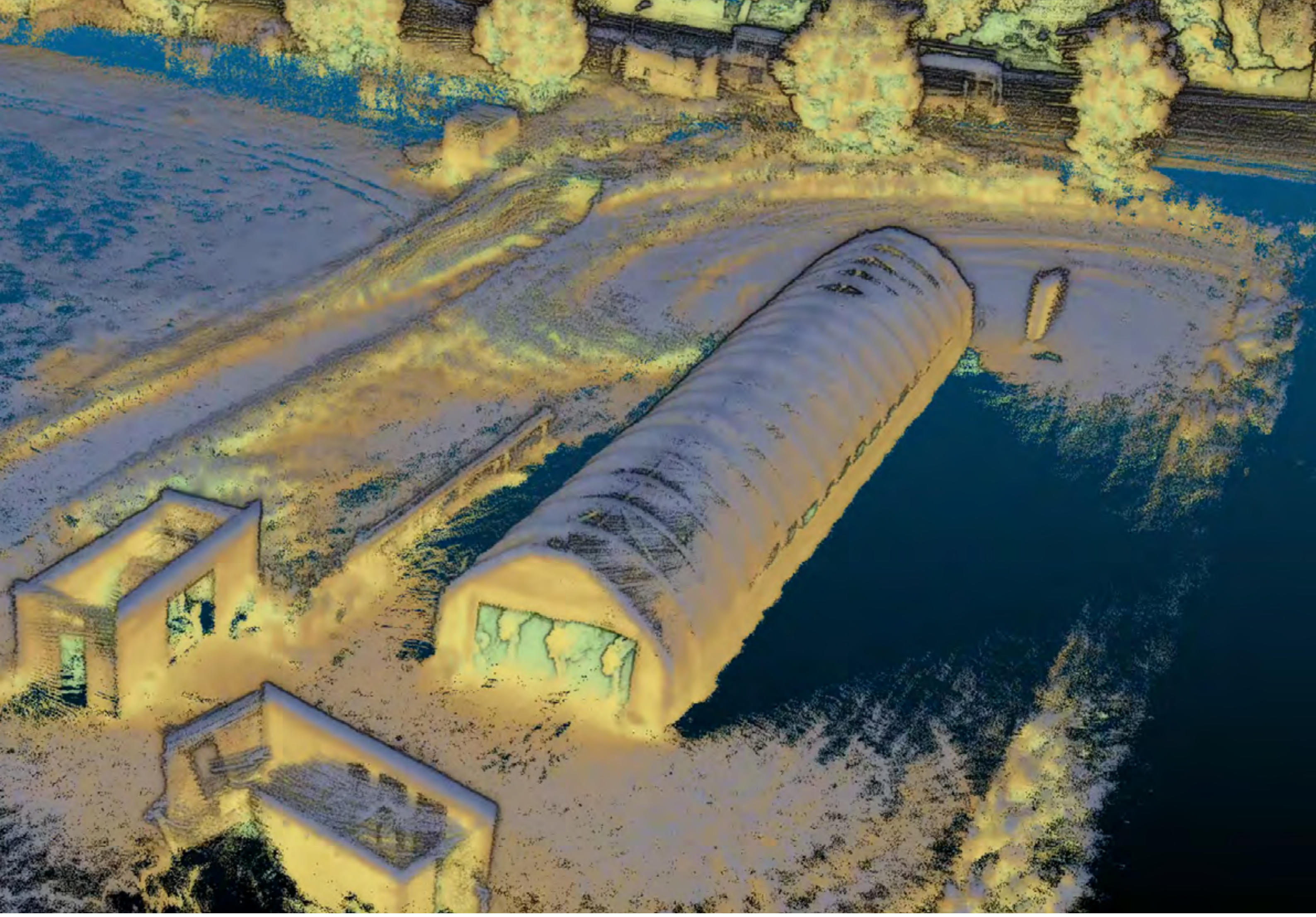
An important task for the The Scientific Advisory Board is to review results and research plans and give advice on research methodology and industrial and societal relevance



• Photo of robot/cc: Anders Hansen, SINTEF

MobileSense inspection robot equipped with navigation sensors and an inspection payload operating around and inside an agricultural polytunnel. Using LiDAR–IMU SLAM, the system creates 3D reconstructions of the environment, showing the tunnel structure, crop tables, strawberry plants, and surrounding area. These maps provide a clear visual validation of SLAM performance, which is critical for reliable autonomous navigation, and allow inspection outputs (e.g., sugar content measurements) to be spatially referenced in 3D, enabling traceability of where observations were made.





Partners

Research partners

Nofima is one of Europe's largest institutes for applied research within the fields of fisheries, aqua culture and food. Nofima's vision is "Sustainable food for everyone", 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 environ – mental and climate footprints. We have excellent knowledge in food quality science and are recognised 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 is contributing with peak expertise in applied spectroscopy (Raman, NIR, fluorescence, FTIR and hyperspectral imaging), process analytical technology, data analysis, consumer science and food science. Nofima also provides an extensive state-of-the-art lab for spectroscopic analysis, food pilot plants and food technology labs. Our key personnel contributing is DigiFoods' Centre Director Dr. Jens Petter Wold, Pillar 3 Lead Dr. Nils Kristian Afseth, Pillar 4 Lead Dr. Ingrid Måge, Dr. Karsten Heia, Dr. Lars Erik Solberg, Dr. Erik Tengstrand and Dr. Paula Varela. A group of about 16 scientists and technicians are also taking part in the research.

UNIVERSITY OF LINCOLN
LINCOLN INSTITUTE FOR AGRI-FOOD TECHNOLOGY

University of Lincoln has established an international reputation for the quality of its research and teaching in agri-robotics. The research undertaken is strongly applied, and it has many links to the local, national, and global agri-food industry. The research facilities include dedicated campuses for agriculture and food manufacturing. Our main contribution to DigiFoods is to provide world-leading expertise in agricultural robotics. Our team is involved in the MOBILESENSE project, supporting the NMBU team in the deployment of mobile robots in real agricultural environments. Our team provides a navigation system software and digital twin of the strawberry farm, together with technical assistance to enable the NMBU team to deploy the Thorvald robot in strawberry polytunnels. The team also actively participates in seminars and project meetings. The University offers further opportunities for the project consortium and welcomes researchers and practitioners from industry to spend time in Lincoln with the objective of strengthening collaboration within the centre. Our key personnel contributing to DigiFoods include Prof. Grzegorz Cielniak and Prof. Simon Pearson.

Ulm University (UULM)) is ranked #19 among German Universities and overall #199 in the world (Times Higher Education Ranking 2025). The Institute of Analytical and Bioanalytical Chemistry (IABC) is leading several national and international projects dedicated to the development of advanced vibrational spectroscopic sensing concepts for industrial, medical, environmental, and food quality/ safety applications. In DigiFoods, IABC provides expertise in food quality and safety monitoring/ sensing technologies, sensing networks, and data mining via advanced analytical techniques and strategies developed at IABC ensuring food safety and public health. Especially, IABC@UULM develops miniaturised mid-infrared sensing platforms based on a wide variety of infrared spectroscopic techniques (FTIR, ICLs, QCLs, IC-LEDs) combined with thin-film waveguides for analysing relevant food constituents, contaminants and (bio)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 is Professor Boris Mizaikoff and his team members working in the field of food analysis. In addition, the partners in Ulm have started an Applied Research Institute – Hahn-Schickard Ulm – focused on translating fundamental research concepts into real-world practice, which directly contributes to the goals of DigiFoods.

NMBU's mission is to contribute to the well-being of the planet through interdisciplinary research and study programs that generate innovations in food, health, environmental protection, climate, and sustainable use of natural resources. NMBU aims to educate outstanding candidates, perform high-quality research, and create innovation.

Two research groups from the Faculty of Science and Technology at NMBU are involved in DigiFoods: the Biospectroscopy and Data Modeling group (BioSpec group) and the Robotics group.
The BioSpec group collaborates with partners such as the University of Ulm, nanoplus, OptoPrecision, and MEMS AG to develop and apply novel handheld and portable infrared devices for food quality measurements. A key focus of the BioSpec group is to advance the use of infrared spectroscopy for field measurements. To achieve this, the BioSpec group is working on innovative sampling approaches tailored to liquid foods and soft food commodities. These approaches include the use of new light sources specifically designed for field applications and the adaptation of infrared spectroscopy techniques for reliable in-field measurements. In addition, we are developing automated sample preparation methods to enable efficient in-field and in-process analyses.
The Robotics group specialises in agricultural robotics and develops autonomous robots for food processing automation, spectroscopic measurements, and data collection. They are responsible for the RoboSense and MobileSense projects. The RoboSense team developed an autonomous robotic Raman spectroscopy

system for in-line omega-3 fatty acid content measurement in salmon fillets. The system uses computer vision, AI-based learning, and motion planning algorithms for faster and more accurate measurements. The MobileSense project uses a mobile robot platform, Thorvald, with a robotic arm for long-term in-field sensing, collecting sugar-content data from strawberries using FragoPro technology developed by SINTEF.

Key NMBU staff is Professor Achim Kohler, the leader of the project Infrared Spectroscopy, Associate Professor Antonio Leite, the leader of the project RoboSense, Associate Professor Weria Khaksar the leader of the project MobileSense and Professor Kristian Hovde Liland from the department of Mechanical engineering and technology management is responsible for the education of master students.

SINTEF

SINTEF AS Smart Sensor Systems 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 contributes by designing and building new sensor prototypes for measurement in industrial processes or in the field, and adapting existing scientific instrumentation to industrial sites for inline process characterisation measurements. SINTEF works 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 are Pillar 1 Lead Marion O'Farrell, Senior Researchers Jon Tschudi, Kari Anne Hestnes Bakke, Anders Hansen and Trine Kirkhus and PhD student, Vilde Vraalstad.

The Universitat Politècnica de València (UPV)
For another year, and 14 years in a row, QS World University Rankings has once again included the Universitat Politècnica de València (UPV) among the 500 best universities in the world. This result joins those obtained by the UPV in the other two main university rankings in the world: ARWU (popularly known as the Shanghai ranking) and THE (Times Higher Education). In its most recent edition, Times Higher Education recognises the UPV as one of the 200 universities with the greatest social and economic impact in the world.

On the other hand, ARWU, considered the most prestigious ranking internationally, highlights the UPV as the best polytechnic university in Spain and includes it, for the 19th consecutive year, in its global ranking of the 500 most important universities in the world. UPV is particularly relevant in the areas of Engineering and Sciences and a national leader in patent license income and start-up creation. The 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, Industrial Statistics, Process Analytical Technology (PAT), Multivariate Image Analysis (MIA), Process Chemometrics and Statistical Methods for Process Improvement and Optimisation. DigiFoods allows us to share our experience working with industry and research-based innovation. In addition, it is an excellent opportunity to be exposed to the needs of the high-tech food industry, opening new research lines to get involved. UPV is providing joint supervision with NOFIMA of one PhD student on data analytics and real-time process control & optimisation. Our key person contributing in DigiFoods is Professor Alberto J. Ferrer-Riquelme.

Food companies

TINE SA is Norway's largest producer, distributor, and exporter of dairy products, with a rich heritage dating back to 1856. As a farmer-owned cooperative, TINE is committed to producing high-quality dairy products while ensuring sustainability, innovation, and value creation for its owners and consumers. The company offers a diverse portfolio, including cheese, milk, yogurt, butter, cream, desserts, and ready meals, with strong brands both in Norway and international markets.

TINE is committed to sustainability, health, and responsible value creation, aiming to reduce emissions, improve animal welfare, and ensure resource-efficient production. By focusing on quality, sustainability, and innovation, TINE continuously enhances its production processes and supply chain efficiency. Through DigiFoods, TINE invests in research and technology to optimise production of cheese, reduce waste, and improve food quality via digital transformation. DigiFoods utilises real-time data analysis and large-scale industrial data to streamline production processes, minimise waste, and boost productivity. This initiative has significantly advanced TINE's value chain, particularly in production of cheese, by using NIR sensors and real-time data to enhance quality control and maintain consistent product quality. Additionally, dynamic recipe adjustments based on real-time ingredient variations have helped maintain consistent texture and flavor in ready meals and ice cream production.
TINE's commitment to tradition and innovation ensures a healthier and more sustainable future for generations to come. Our key contributors in DigiFoods are Director R&D Anne-Cathrine Whist, Technology specialist in Cheese and Start Cultures Jorun Øyaas, Manager R&D Cheese and Fat Products Kjetil Holstad, Technology Specialist Cheese Kjetil Jørgensen and PhD student Åse Riseng Grendstad.

Nortura is the largest brand supplier in Norway in the meat and egg business, our main brands are Gilde and Prior. We are organised as a cooperative, owned by more than 15 500 Norwegian farmers that supply more than 260 000 tons of raw material from all relevant animal species to our slaughter- and processing plants. Nortura slaughters, cuts, refines and develops meat and egg products that are sold to retailers, restaurants, food-services 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 35 National and international research projects. In DigiFoods we concentrate our work on our poultry, beef and pork value chains using sensors and big data. We expect to optimise our production and processing lines and hope to get more value out of our raw material. By optimising 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 high quality products in the future. Our key personnel contributing in DigiFoods are Research Director Per Berg, Quality and Project Manager Karl Helge Albretsen and Technology Manager Hans Christian Gutu..

Wiig Gartneri is a family-owned business that has been passed down through generations since 1937. Today, it stands as one of Norway's largest greenhouse producers. We specialise in growing various tomato and cucumber varieties, which are distributed nationwide. In addition, we operate a packaging facility, a food processing department, a crop production unit, and our own retail store. One of our main products is the Piccolo tomato, for which we are the only licensed producer in Norway and one of 17 in Europe. This tomato is known for its high dry matter content and exceptional sweetness. Our goal is for every customer to experience the same level of quality with each purchase, and our participation in DigiFoods is therefore based on improving the standard of this tomato variety. Together with DigiFoods, we have tested and explored the potential of implementing in-line Near-Infrared (NIR) measurements in production to identify the sugar content. This technology has shown promising results, indicating that NIR can be used to ensure consistent quality. DigiFoods has supported our goal by exploring measurement methods to secure high product standard while also strengthening our network and collaborations with key partners. Moving forward, we aim to integrate different technologies and contribute to the development of quality assurance in the fresh produce industry. Our key personnel contributing to DigiFoods are Production Manager Frode Ringsevjen and Sales and Marketing Manager Martine Tjåland.

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 explores new possibilities to refine different raw materials by the use of bioprocesses.

In SFI DigiFoods, Norilia has made the process line at Bioco available for development and use of new sensor systems and optimisation approaches, as well as for pilot and industrial testing. Our collaboration with research partners has showed that thorough applying sensor systems like NIR, Raman spectroscopy and dry film FTIR spectroscopy, it is possible to predict the quality of protein hydrolysates based on variation of raw materials and process parameters. This collaboration allowed us to gather knowledge and develop tools that will enable us to optimise and control our processes with the help of sensor systems. Norilia also investigate and develop novel solutions for wool grading using advanced hyperspectral imaging technology.

Norilia will continue to contribute to SFI DigiFoods with our competence and know-how on enzymatic hydrolysis, raw materials, ingredients, applications and markets, as well as access to Bioco for further research and development. Our key personnel contributing to DigiFoods include Director of Business Development Heidi Alvestrand, and Chief Advisor Bioprocesses Piotr Chylenski, along with staff at Bioco. Heidi has also been elected Chairman of the Board.

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 are very promising and are both of a generic nature (sector independent) as well as specific for our business. Our key person contributing in DigiFoods is 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 underutilised side streams from the salmon industry. Biomega's mission is to transform undervalued, food-grade, raw material into premium food and petfood ingredients through accelerated biorefining. Through the DigiFoods project, we have been and will be an industrial test facility for new in-line monitoring solutions, and our expectations is that along the DigiFoods lifespan new online/in-line process monitoring equipment is devolved that could contribute to a more stable production and end-product quality. This far, we have focused on the characterisation of the raw material entering our production line, and we are able to distinguish different raw materials by online measurements. In the remaining project period, we will improve the online/in-line measurements of the input to the biorefinery and try to characterise our hydrolysed protein products. Our key personnel contributing in DigiFoods are Silje Steinsholm and CSO 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. french fries, 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 learning from other food companies with similar challenges. Our key person contributing in DigiFoods is 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 i-proved 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 person contributing in DigiFoods is Operation Manager Odd Johan Fladmark.

Sensor & Robotic

Lerøy Norway Seafoods s Lerøy's quality brand for sustainable white fish 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 world-wide. 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 utilisation 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 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 persons contributing in DigiFoods are Jørgen Kvinge and Roy Martin Martinsen.

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 recognised 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 customised 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 to 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.

Half-way through the project we have proven feasibility of using our cameras for tomato and wool quality grading, with project partners Wiig and Norilia, respectively. With both partners we will be looking into options for integrating the technology into their production line. We are also working with Maritech to improve data quality through enhanced illumination systems.

Our key personnel contributing in DigiFoods is Applications Specialist Na Liu, Solutions Manager Lars Gidskehaug, Hyperspectral Applications Manager Julio Hernandez, and CEO Trond Løke.

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 contributes to DigiFoods by bringing in capabilities and related expertise in the field of ICL and QCL technology. DigiFoods enables us to maintain a strategic position with respect to emerging technology and related market opportunities concerning infra-red emitters in the food industry field, and to related investigations for future device applications in biophotonics. Our key person contributing in DigiFoods is Johannes Koeth.

MarqMetrix part of Thermo Fisher Scientific 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 optimisation. Our fast and non-destructive sampling technology allows you to simply “touch” a sample to analyse gasses, liquids, solids and slurries. MarqMetrix has years of experience using Raman spectroscopy for analysing lipids, collagen, and carotene concentrations in salmon fillets and cooking oil. We are excited about our participation in DigiFoods because it enables 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 are CEO Brian Marquardt, VP of Data Analysis Thomas Dearing and VP of Strategy Marc Malone.

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 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 also offer an autonomous robot for field trials with sensors. Saga will work on integrating sensor systems on field robots and testing these in the field.

OptoPrecision GmbH is a small, yet leading company in research, development, and production of high-quality optical sensing devices and solutions. Today, we address our products applications in the chemical and steel industry, security and observation business and also in the pharmaceutical market. The strategic goal of OptoPrecision is to strengthen and expand its business via network activities 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 are contributing 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. First demonstrators have been built in 2021 and have been tested together with coworkers from the NMBU and UUlm team in 2022. In particular, we have realised a mid-infrared laser-based spectroscopic measurement setup for analysis of liquid samples. The system can operate different single wavelength lasers and is unique in both its precision and ability to handle larger volumes of liquids in transmission measurements compared to existing spectrometers. The instrument is ready to be tested for liquid food products in DigiFoods. The instrument has been located at NMBU since 2024 and is ready for use for tests in the industry. In general, DigiFoods provides a partner network and an excellent basis and opportunity to discuss, develop and push innovative ideas towards the market. OptoPrecision works closely with NMBU, Ulm University and nanoplus on technology development.

With the move of Dr. Markus Nägele, the key person contributing in DigiFoods, from OptoPrecision GmbH to MEMS AG during the fall of 2025, OptoPrecision lost its expertise in the field of laser spectroscopy and fluid analysis. For this reason, MEMS AG joined the DigiFoods consortium as an industrial partner, thus replacing OptoPrecision's partnership in the centre. MEMS AG has developed highly innovative gas measurement technology in recent years and is constantly on the lookout for further technologies and areas of application. From the perspective of those involved, the cooperation with DigiFoods will thus continue seamlessly and successfully.

Digital platforms, software and analytics

aspentech

Emerson's Aspen Technology business is a global leader in industrial software, powering the future of the world's most critical industries. By driving innovation through AI-powered, model-based solutions that accelerate digital transformation, the AspenTech software portfolio enables customers to design, operate and maintain complex industrial operations with greater performance, safety and environmental responsibility, to not only improve their economic return, but build a better future for our world.

DigiFoods addresses the critical knowledge and technology gaps that must be bridged to achieve successful digital transformation for the food industry. A collaboration with DigiFoods provides deep, data-driven understanding of food quality, processing efficiency, and real-time production variability. Their expertise in advanced sensors, robotics, and digital analytics provides Aspen Technology with a strong foundation for understanding industry needs across the food value chain. Our key personnel contributing in DigiFoods are Principal Consultant Engineer Simon Thain, Principal Data Scientist Carol Roach, Product Manager Janet Blancett and Principal Enterprise Solution Consultant Robert Zuban.

Idletechs AS was founded in order to stimulate the digitalisation in the industry. We develop fundamentally new tools combining multi-channel sensors, transparent machine learning methods, and domain knowledge. 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 thermal and hyper-spectral software in the food production chain and simplify the integration of multichannel sensor data from various sources in the food production sector. DigiFoods provides important market contacts and user feed-back for Idletechs and enables us to position us in the market. Our key personnel contributing in DigiFoods are Technical Director Torbjørn Pedersen and Project Manager Frank Westad.

Maritech is the world-leading provider of seafood software, enabling full traceability, data flow and process support from sea to table. From catch and landing, through production, processing, packing, sales, and logistics. In addition to business systems, packing solutions, data, and IoT, Maritech has specialised in hyperspectral technology. Using Maritech Eye™, seafood companies can now run objective, automated quality inspection of red and white fish at industrial speed. As part of DigiFoods, this system has been fully implemented at Lerøy Aurora measuring fat content, colour, blood, and melanin spots in salmon fillets. In the coming period we aim to combine these measurements with production data to gain new insight and to improve processes. In collaboration with Lerøy Norway Seafoods a solution for whitefish fillets has been developed identifying blood spots, parasites, and skin/fin remnants. This solution is now in commercial use at Samherji in Akureyri, Iceland. Another large ongoing activity for Maritech in DigiFoods is to identify more robust illumination systems that do not rely on halogen lamps.
Two new prototypes have been designed by Norsk Elektro Optikk and will be tested in the coming period. Our key persons contributing in DigiFoods are Project Manager Silje Ottestad, System Developer Håvard Løvik and R&D Manager Hardware Jan Rune Herheim..

Intelecy is an innovative SaaS company with a clear goal of enabling sustainable production within the industry. Intelecy's no-code Industrial AI platform is built for industrial data and made for industrial citizens. The easy-to-use tools enable engineers and operators to create, use and operationalise sophisticated AI algorithms without prior coding knowledge. By using Intelecy, a wide range of industrial companies improve resource utilisation, prevent unplanned downtime, increase capacity, and minimise their environmental impact.

The DigiFood's project has made significant progress in implementing and evaluating artificial intelligence solutions in Norwegian cheese production, with particular success at TINE Jæren, Norway's largest dairy facility. By leveraging their innovative platform, Intelecy has enabled continuous real-time data processing from thousands of sensors, making advanced analytics accessible to TINE's production staff without the need for specialised data science expertise. Their contributions include the provision of a no-code industrial AI platform, development of tools for detecting patterns in temperature and pH values, and implementation of machine learning models for process optimisation and quality control.

The project has led to significant advancements in cheese production optimisation and quality enhancement. Intelecy's analysis of process parameters has helped standardise production, resulting in increased cheese output and improved product consistency. Additionally, their work has identified critical factors influencing cheese quality, leading to potential increases in production efficiency, highlighting the transformative potential of AI in the dairy industry, providing valuable insights and methodologies for future research and development.

Article

Smart sensor can turn food waste into high-quality protein

by Johanne Høie Kolås, NMBU

Every year, large amounts of leftovers from the food industry, so-called side streams, are either turned into low value products or discarded. A smart new sensor can help the industry make better use of these materials by monitoring and controlling the process that turns them into high value protein.

When food products are made from meat and fish, substantial by products remain, such as skin, bones, or shells. With novel biotechnological processes, materials that currently end up as low value products or waste can instead be turned into valuable compounds.

One such compound is protein. Many companies are trying to convert these leftovers into protein rich ingredients for use in animal feed, dietary supplements, and functional food products.

"Demand for protein is increasing globally. New technology can help the food industry become more sustainable, more efficient, and better prepared for the future," says Bijay Kafle.

A smart sensor to assess protein quality

Kafle is a researcher at the Norwegian University of Life Sciences (NMBU). There, he works on the IR project, which is part of the DigiFoods centre. In this project, researchers are developing infrared sensor technology that can help industry monitor and control the quality of their food processes.

The food industry can use this technology to optimally extract high quality proteins from residual raw materials. These proteins are called protein hydrolysates. Hydrolysis industries currently use these hydrolysates mainly as animal feed. Now they are looking to produce them as a human grade protein ingredient as well. To succeed in that, the protein hydrolysates must be high-quality.

Extracting these proteins from the raw materials is challenging. One common method is enzymatic hydrolysis. The raw material, such as fish carcasses, is grounded and hydrolysed using enzymes that break proteins into smaller fragments. During hydrolysis, the protein composition changes continuously depending on the raw material composition and process parameters. As a result, the quality of the final product varies throughout the process.

In this process, precise control is essential. But today's conventional quality assessment methods are time consuming, costly, and carried out in laboratories far from the production line.

"Current spectroscopic tools, such as commercial infrared spectrometers, are large, require manual sampling, and must be operated by trained personnel. They are also sensitive to heat, moisture, and dirt, which make them poorly suited for harsh industrial environments," says Kafle.

Lab results take time, so production often continues unchanged while quality varies. "When protein quality changes rapidly throughout the hydrolysis process, it's crucial that the sensor can track these changes and measure quality in real time," says Kafle.

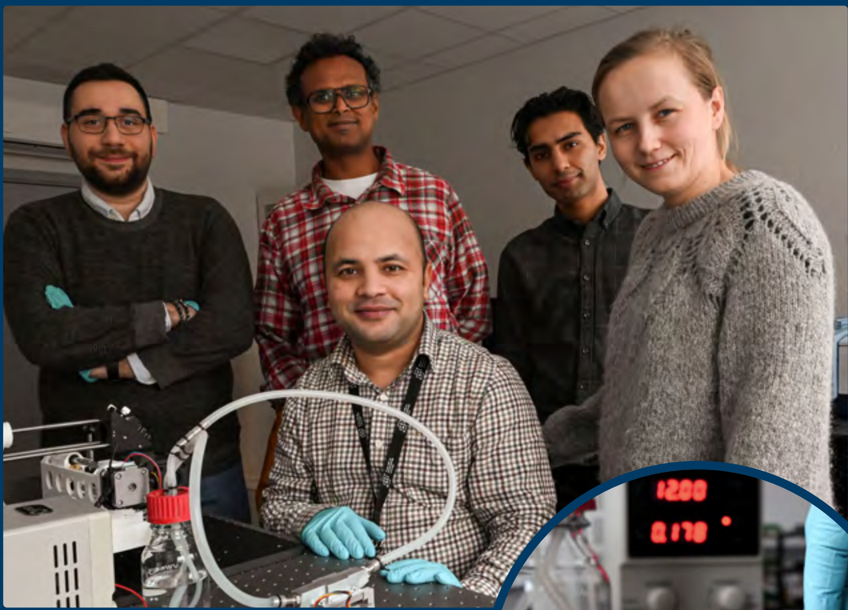
Research performed at Nofima shows that variation in raw materials, enzyme types and process parameters, such as temperature, water addition and flow rate, affect the composition of the protein hydrolysates.

While spectral data from offline infrared measurements can be linked to hydrolysate quality and differences in raw materials quality and enzyme types, these analyses are performed too late to support real-time process control. A fast, robust sensor capable of measuring protein composition inline, directly in industrial production lines, is therefore still missing.

Compact, lightweight and automated

The NMBU researchers hope to solve this problem using mid infrared light and advanced data modelling. In a spin-off project of the DigiFoods centre, the SmartSense4Protein project, the team is developing a compact sensor that can be installed directly in the production line and

Photos/cc: Johanne Høie Kolåsd, NMBU



Researchers from BioSpec Norway at Norwegian University of Life Sciences (NMBU) – back row, from left: Mehmet Can Erdem, Michael A. A. Fenelon, Pranish Karki, and Maren Anna Brandsrud; front row: Bijay Kafle – pictured with a flow-cell–based IR spectrometer (highlighted in lower right corner) designed for inline measurement of protein solutions.

monitor protein hydrolysis continuously. It extracts small samples automatically, every minute during processing. The plan is to use the data in a digital twin which in the future will control the process to obtain a stable and high product quality.

"Inline measurement of protein hydrolysates directly from the process lines is challenging," says Mehmet Can Erdem. He is a PhD student in DigiFoods, where he works with infrared sensor development and data analysis.

"The process is highly dynamic and samples are heterogeneous and difficult to measure consistently with conventional spectroscopic tools. This motivates new inline sensing techniques based on direct interaction between the light and the material," he says.

Protein hydrolysates are complex mixtures of oil phase, water phase, and solid phase. The water phase is rich in peptides and amino acids, which are the most important for nutrition and quality. Sample preprocessing is necessary to separate these phases, which is done in a bypass loop. This water phase is therefore separated and sent to a flow-cell for analysis.

The sample flows through a flow cell – a small measurement cell through which liquid can pass – allowing analysis without stopping the process. Inside the flow cell, the sample is illuminated with mid infrared light, which provides detailed information about its chemical composition.

Data models interpret the infrared signals

By using advanced data models, the system can convert infrared signals into meaningful quality metrics, such as peptide levels, changes in molecular size, and collagen content. This provides a real time snapshot of how far the hydrolysis has progressed. "This allows us to monitor and control the process with high precision, even when the raw materials vary", he says.

When each measurement is completed, the system cleans itself automatically. This allows it to deliver continuous and stable measurements without manual intervention.

Technology for the food industry of the future

The smart infrared protein sensor is being developed specifically for use in industrial food production. The researchers work with DigiFoods partners Biomega and Bioco, who provide real industrial samples from their factories. These allow the team to tailor the setup to industry needs.

"The goal is to move from prototype to full industrial demonstration, ensuring the system is robust, reliable, and easy to integrate into existing production lines," says Kafle.

The infrared device is also designed with future digital food production in mind. The system can feed real time data into digital models of the production process, enabling prediction of outcomes, performance optimisation, and improved traceability.

Kafle believes the technology could have a significant impact on the food industry. With better real time control, companies can make better use of raw materials, reduce waste, and turn by products into valuable ingredients for food and feed.

"This supports the broader vision of Industry 4.0, where extensive digitalisation connects factories, people, and products into intelligent and efficient systems," he says.

4. Scientific activities and results

Pillar 1 Novel sensor systems and application development

In this Pillar, we focus on the development of novel sensor systems and measurement methodologies that enable robust, in-line and in-field measurement of food quality attributes. The work spans high-resolution spectroscopy, hyperspectral and multispectral imaging, and low-power, miniaturised spectral sensors, with a strong emphasis on non-contact measurements and deployment under real industrial and outdoor conditions.

In 2025, the activities in Pillar 1 increasingly centred on bridging fundamental sensor understanding with real-world operation, ensuring that measurement solutions remain stable and reliable despite variations in raw materials, process conditions and ambient environments. Building on earlier developments, we advanced online and inline applications based on hyperspectral imaging, NIR, FTIR, Raman and IR spectroscopy, in close collaboration with industrial technology providers including Maritech, NEO, MarqMetrix, Nanoplus and OptoPrecision. Several sensor prototypes were further matured and validated through field trials in food production lines and agricultural environments, in close interaction with Pillar 3.

A key development in 2025 was the continued miniaturisation and system integration of NIR- and IR-based sensors, enabling new application areas such as robotic sensing in agriculture, non-contact core temperature estimation in processed foods, and inline quality control of heterogeneous raw materials. The work has demonstrated how first-principles understanding of light–matter interaction and the effect of external, real-world disturbances can be translated into more robust sensor designs, improved calibration strategies and greater transferability between laboratory, pilot and industrial settings.

Exploration of new opportunities and innovation pathways remains an integral part of Pillar 1, contributing actively to positioning DigiFoods within the EU landscape through input to Photonics21 and relevant photonics and spectroscopy call texts, supporting long-term access to European funding instruments.
Pillar 1 is led by Marion O’Farrell (SINTEF Digital). Key end-user industrial partners in this Pillar include Lerøy Aurora, Lerøy Norway Seafoods, Lerøy Havfisk, Nortura, Norilia, Biomega and TINE, who contribute critical insight into industrial requirements and serve as testbeds for validation of new sensor technologies.

FTIR

FTIR spectroscopy is a technique that generates highly resolved, information-rich spectra. One of the intriguing aspects of FTIR is the possibility for characterisation of proteins, not only protein content, but also protein quality, like for instance protein structure, peptide size distribution, and even protein composition. Since water very efficiently absorbs infrared light, FTIR spectra of aqueous samples (like in food-based products) will often be dominated by water absorption. Dry film analysis, on the other hand, has proven to increase sensitivity towards specific analytes compared to the direct analysis of liquids. Dry film FTIR analysis is therefore particularly interesting related to protein characterisation, since multiple protein-related infrared absorbances could be “buried” when water is present in the sample.

A milestone of the project was achieved in the successful development of a portable FTIR system for dry film measurements that can be used close to industrial process lines

In Digifoods, two applications of dry film FTIR spectroscopy have been particularly addressed: the characterisation of protein hydrolysates, in collaboration with Biomega and Bioco, and the characterisation of milk proteins, in collaboration with Tine.

A milestone of the project was achieved in the successful development of a portable FTIR system for dry film measurements that can be used close to industrial process lines, enabling industrially relevant measurements. This is a technological solution that is currently not commercially available. The work in 2025 has mainly evolved around this portable dry film FTIR system, involving three different directions:

1. development of sampling opportunities;
2. calibration development; and
3. calibration transfer.

The prototype dry film FTIR system currently requires manual sample handling, and any automation of the sample handling will contribute to a more efficient analytical device. Thus, in 2025, SINTEF has tested the use of a cheap 3D printing device for effective transfer of liquids to a silicon wafer. The results so far are promising and will be followed up in 2026. Calibration development has mainly been related to building robust calibrations for protein hydrolysate characterisation of products from the Biomega factory, and in particular the viscera processing line of this factory. This work has been done in close collaboration with the RCN-funded project "SmartSense4Proteins" led by NMBU, and the IR project. The calibration results so far are positive, and calibration work will extend into 2026. When calibration work is finalised, we also plan to bring the portable dry film FTIR system to the factory for extensive process and product characterisation.

At the current development stage, the main intended use of the portable dry film FTIR system is related to process documentation, process optimisation and process development in a range of food and bioprocess industries. A prerequisite in this respect is swift and robust calibration development. We have therefore shown that calibration transfer from an extensive database of calibrations obtained on our benchtop high-throughput dry film FTIR system is possible for a range of relevant chemical components and matrices, including protein hydrolysates, milk, juice, microorganisms and fermentation samples. This clearly enables rapid and robust development of calibrations for monitoring of a variety of foods and bioprocesses, allowing the use of the portable FTIR system in a variety of different industrial applications. This also shows that the FTIR optics are comparable across different instrumentations. A publication on the calibration transfer possibilities related to the portable dry film FTIR system is expected during 2026. Moreover, we will continue to pursue and develop the portable system as part of a concept for manual process understanding and process development in industrial environments.

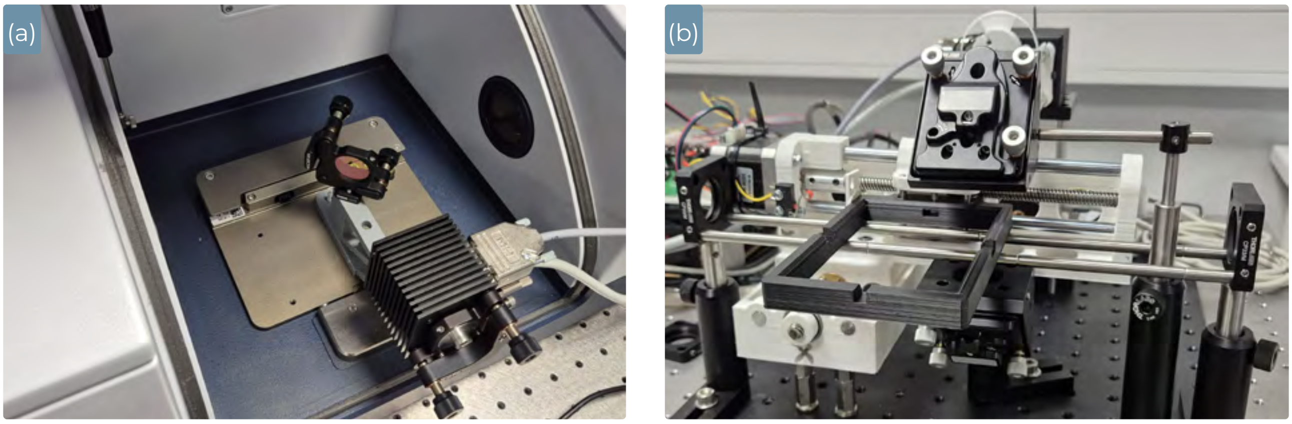
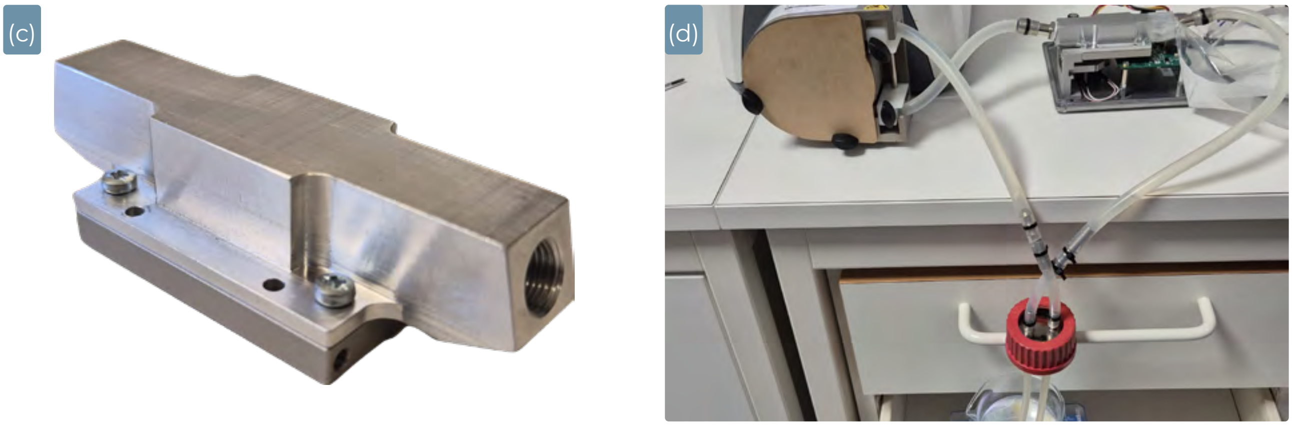


Fig. 1: Optical setup implemented to characterise the tunable ICL (a). Mid-infrared tunable laser-based dry-film transmission setup for measuring proteins in aqueous solutions (b).



Photos/cc: Pranish Karki, NMBU

Fig. 2 The ATR flow cell designed for inline measurements (a). The flow cell is tested in simulated liquid flow setup using peristaltic pump, sample solution, and LED-based spectrometer (b).

IR

The BioSpec group, in close collaboration with the University of Ulm and our industry partners nanoplus, OptoPrecision and MEMS AS, has continued to advance the development and application of innovative handheld and portable infrared (IR) devices for food quality measurement. A major focus of 2025 has been the comprehensive characterisation and testing of our novel tunable interband cascade (ICL) lasers (TL1 and TL2) (Fig. 1a), developed in partnership with nanoplus. Both lasers were rigorously evaluated for emission accuracy using a Bruker FT spectrometer. This process successfully established stable and precise emission points, confirming the high potential of these lasers for accurate food component analysis. Following these tests, the tunable laser was integrated into our transmission measurement setup (Fig. 1b), enhancing both design robustness and signal stability. The transmission setup underwent further optimisation, particularly in terms of design and signal reliability. The upgraded setup was used to analyse BSA dry-film samples and protein hydrolysate samples from Bioco and Biomega hydrolysis facilities. The resulting spectra displayed a high degree of correlation with reference spectra, underscoring the analytical performance and reliability of our system in real-world sample scenarios.

We have defined a new waveguide concept tailored for measurements close to production environments

Significant advancements have also been made in the development of a new flow cell system (Fig. 2a). The design features a 9–reflection ZnSe ATR crystal with a 12–degree angled flow path, which greatly improves sample flow and interaction with the detection surface. The flow cell has been subjected to extensive testing, including flow analysis using a peristaltic pump and spectroscopic analysis of glucose samples (Fig. 2b). These analyses employed a thermal source and a pyroelectric line array detector equipped with a linear variable filter, demonstrating the versatility and effectiveness of the flow cell for liquid sample measurements.

The integration of the tunable laser technology, combined with advancements in flow cell and waveguide-based measurement systems, provide a robust foundation for versatile, in-line, and near-production food quality assessments. Further, we have defined a new waveguide concept tailored for measurements close to production environments (such as hydrolysates) and, potentially, on-farm applications (e.g., milk analysis). The flow cell will be integrated in and tested for bioprocesses in the remaining project period. To this purpose we are currently evaluating different processes for sample homogenisation, that will be integrated into an industrial prototype for online measurements.

The group has actively contributed to scientific dissemination, with several papers submitted on key project developments, including the detection of lipids in food materials, the advancement of the waveguide-based system, and the development of our high-throughput screening (HTS) system.

RAMAN

The project RAMAN is studying how Raman spectroscopy can measure quality parameters such as fatty acid and protein composition in different foods. The focus of the project is on novel sampling strategies and the use of state-of-the-art technology to reduce sampling time and make Raman suitable for process measurements.

During the first five years we have evaluated Raman for rapid and non-contact assessment of fatty acid features (EPA+DHA) in intact salmon fillets and in-line continuous monitoring of fat, protein, collagen and bone in the poultry rest raw material entering the process of enzymatic hydrolysis at Bioco. We have used a non-focused stand-off probe from MarqMetrix – (now Thermo Fisher Scientific) that enables scanning of heterogeneous foods and streams, and this approach seems very feasible. High quality spectra can be collected in seconds. This work was the basis for the PhD thesis of Tiril Aurora Lintvedt and what she has continued with as a post-doc.

In 2025 we concentrated on three interesting topics:

1. When using Raman stand-off probes, the distance between instrument and sample can vary. This will often require some kind of spectral pre-processing. We have done systematic experiments to elucidate how such processing can be done in the best possible way with the aim of developing a protocol for efficient pre-processing of in-line Raman spectroscopy. We utilise the sapphire Raman band for intensity normalisation and the nitrogen band to correct for varying distance.

Photo/cc: Tiril Lintvedt, Nofima

Photos/cc: Katinka Dankel, Nofima

Photo/cc: Tiril Lintvedt, Nofima

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Calibration setup in lab, mimicking in-process measurements in pipe (a). In-line process implementation of fiberoptic Raman and NIR-probes side-by-side in Biomega's facility in Sotra (b). Salmon rest raw materials arriving in the process before being ground and measured by Raman and NIR (c). In-line sampling for validation (d).

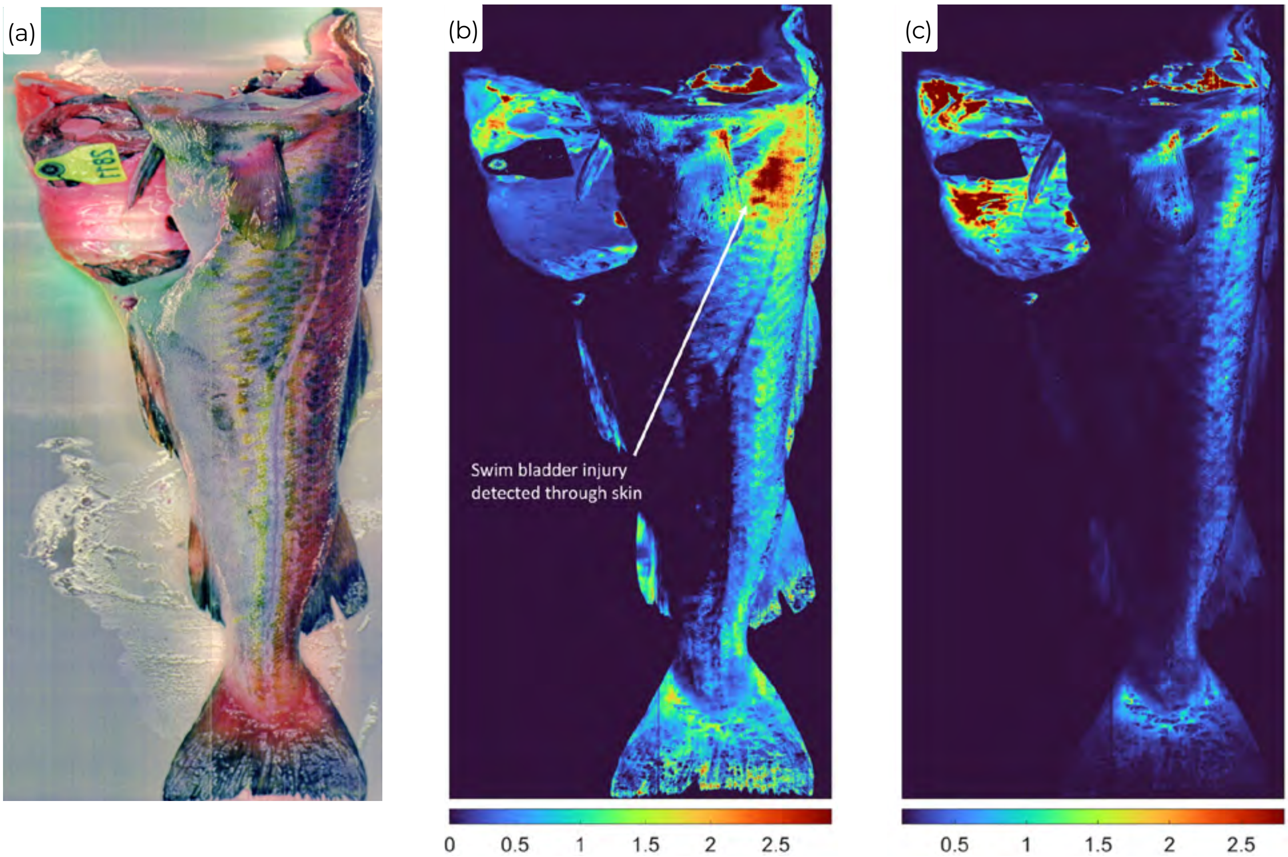
The work has been submitted for publication and we plan to test the strategy in industry. NIR spectroscopy is well established as an in-line method in the food industry. We have benchmarked Raman against NIR and outlined the pros and cons with the two methods on food applications. We have found that Raman can be more robust towards varying sample texture/structure compared to NIR. At least, much simpler calibrations can be obtained. This is an important aspect to consider when choosing the method to use for a certain application. This work was published in 2025.

2. We did compare Raman and NIR side by side in the industrial process at Biomega in 2025. They were used to measure fat, water, and bone in ground salmon by-products. The two instruments were calibrated in the lab at Nofima and then installed in the factory to measure the stream inside a pipe. Measurements were done over about four weeks, and NIR seemed to perform best. In-line NIR showed promise for fat and dry-matter measurement, though further calibration work remains. Raman proved difficult due to highly variable scattering and spectral fingerprints, which hindered robust preprocessing and model development. Practical issues with the Raman probe installation and spectral acquisition further reduced confidence in sample representativeness during in-line validation, leaving insufficient data for a solid comparison with NIR. Nonetheless, the work yielded important practical insights for future in-line Raman implementation.

The work has so far been a collaboration between MarqMetrix, Aspentech, Norilia, Lerøy Aurora, Biomega Group and Nofima.

HYPERSPEC

HYPERSPEC focuses on research activities exploring new and promising applications of hyperspectral imaging relevant to the seafood industry. In particular, special attention has been given to the use of the Maritech Eye (Maritech and NEO) as an in-line instrument for quantifying several quality attributes in different fish products. The activities carried out in 2025 continue to build on these objectives.



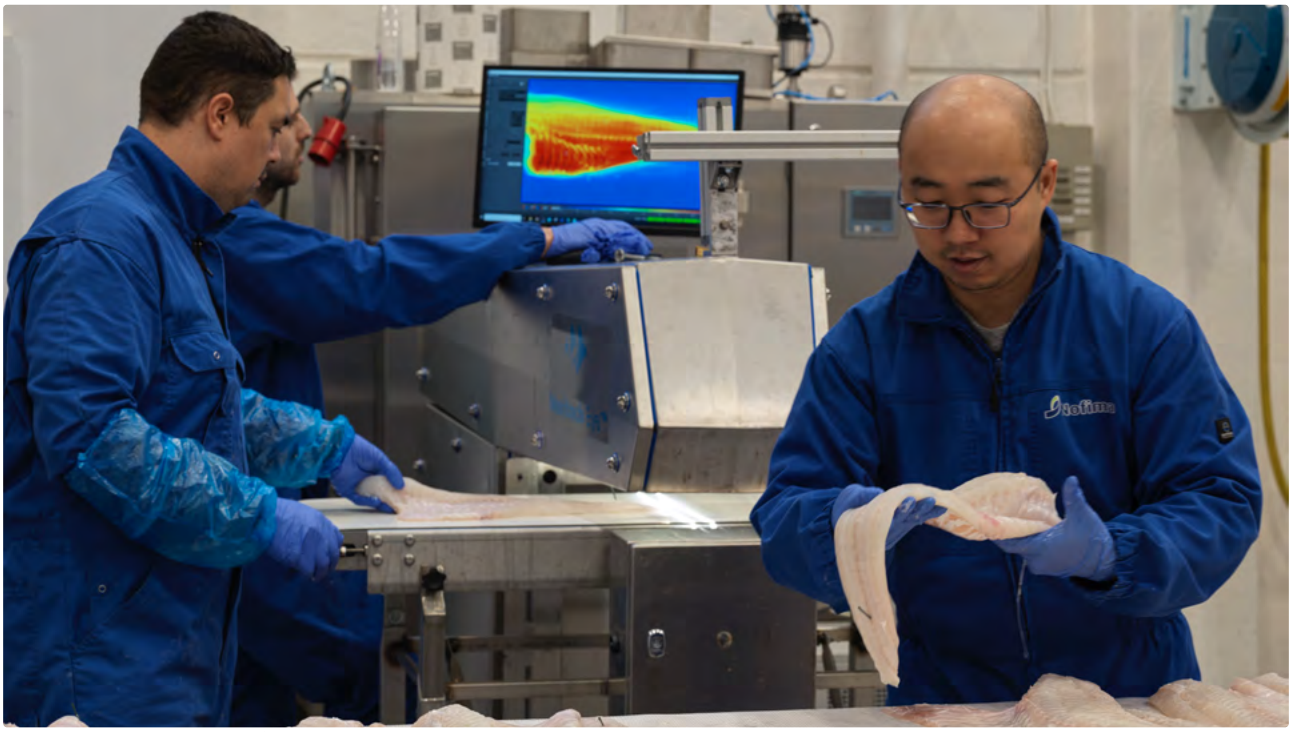
Photos/cc: Rowan Romeyn, Nofima

(a) Contrast-enhanced RGB false color image of headed and gutted whole fish, (b) neural network model blood prediction showing detection of swim bladder related bleeding through the skin, and (c) spectral unmixing blood prediction using empirical exponential calibration function (Rowan Romeyn, Nofima)

Residual blood in fish muscle negatively affects appearance, taste, and shelf life, leading to substantial economic losses for the seafood industry. While previous studies have successfully detected blood in exposed muscle, identifying blood located under the skin remains a challenge, underscoring the need for more advanced, reliable methods. Researchers from Nofima addressed this gap by collecting hyperspectral data in the VNIR range (450–950 nm) using interactance illumination. Data from controlled experiments on cod muscle samples with known blood concentrations, both with and without skin were used to train a compact neural network capable of recognising spectral features associated with hemoglobin. The resulting model demonstrated high accuracy across all tested concentrations and significantly outperformed traditional spectral unmixing approaches, particularly when blood was obscured by skin. When tested on industry-relevant samples of headed and gutted cod, the model successfully revealed subcutaneous bleeding that conventional methods failed to detect. This approach, recently published in the Journal of Spectroscopy, has the potential to enhance the precision and automation of quality assessment in whitefish processing, thereby reducing waste, improving consistency in grading, and increasing product value.

In another activity conducted in HYPERSPEC, the main goal was to gain deeper insight into how spectral data evolves over time during storage. This research was motivated by an ongoing project, funded by FHF and carried out by Nofima, whose main objective is to develop robust algorithms for determining shelf life in cod fillets. The study aimed to better understand how the spectral information changes during chilled storage. To achieve this, fillets were stored on ice and scanned repeatedly over several days using hyperspectral imaging, creating a detailed timeline of how their spectral characteristics evolved. Two imaging systems were employed to cover the spectral range from 400 to 2500 nm (VNIR and SWIR), each using different illumination modes (interactance and diffuse reflectance, respectively). The analyses revealed clear temporal patterns in the spectral data, which

Photo/cc: Audun Iversen, Nofima


Hyperspectral imaging of cod samples with the Maritech Eye system to assess spectral changes during chill storage

could be described using mathematical models previously applied to biochemical degradation in cod fillets. The results indicate that deterioration does not occur uniformly across the fillet, and the belly region degrades more rapidly than the rest. An additional observation was that the rate of spectral change differs among individuals, suggesting that fillets from the same batch may follow different degradation patterns. This highlights the necessity of individual-level shelf-life assessment. The results of this study may provide valuable insights to complement predictive models for shelf-life estimation based on hyperspectral information.

NIR

In 2025, the NIR activities further consolidated the centre's first-principles approach to developing robust spectroscopic solutions for real-world applications, while moving several technologies closer to industrial deployment and commercialisation.

A major scientific milestone was the completion and publication of the first clipfish journal article, which quantified the bulk optical properties of dried salt-cured cod with varying water content. The study provided fundamental insight into how light propagates in highly scattering food products and how these properties influence NIR interactance measurements. This work significantly strengthens our understanding of light behaviour and can help improve the robustness of our instrument design and prediction models. The continuation of this work will be published in 2026, where we will explain how the fundamental understanding of the NIR signal is reflected in the calibration models.

It is directly applicable to clipfish as well as other complex food matrices. The results also form an important scientific foundation for the **SenseInside** technology platform. Vilde Vraalstad presented this first-principles methodology and its application to food systems at two major international conferences in 2025:

- **Photonics West** (San Francisco, January 2025): *"First-principles methodology for developing robust NIR spectroscopic solutions for real-world applications"*
- **NIR2025** (Rome, June 2025): *"Unravelling light–matter interaction of complex food products to improve the robustness of near-infrared spectral measurements"*

In addition, Vilde held her PhD midway seminar in 2025, marking an important academic milestone and confirming the scientific direction of the work.

During the year, we further developed and tested the FragoPro sensor, a compact visible–NIR spectroscopic instrument for non-contact measurement of sugar content and colour in

A key contribution this year was the continued maturation of SenseInside from a research prototype toward a pilot-ready system

Photo/cc: Jon Tschudi, SINTEF

Industrial testing of SenseInside of meat content in live king crabs at Lerøy in Kjøllefjord.

fruits such as strawberries and tomatoes. The sensor is designed for integration on autonomous robotic platforms (e.g. Thorvald) such as explored in Pillar 2, enabling selective harvesting and monitoring of crop ripeness over time. Building on earlier work, where we measured strawberries in the NMBU polytunnel at different times during the day, we conducted controlled laboratory measurements on strawberries in 2025 as a basis for a sweetness prediction model that could be applied to field data. The work resulted in a journal article (submitted in 2025, to be published in 2026) that systematically investigates the impact of challenging real-world conditions such as ambient light and outdoor operation. The results demonstrate that non-contact NIR measurements of on-the-plant strawberries in variable ambient light are feasible, an important breakthrough for agricultural robotics and field-deployable sensing. Measurements have now been demonstrated with good performance both at night and in full daylight, despite strong and variable ambient illumination. The ability to probe relatively deep into the product without physical contact makes this technology particularly attractive.

In parallel, significant progress was made toward commercialisation of the SenseInside technology. The verification project (Kommersforsk – 341632) is nearing completion, a patent application has been submitted, and SINTEF TTO is actively engaged in supporting the next steps toward market introduction. As part of this effort, the SenseInside instrument was demonstrated to clipfish production companies during an industrial visit to Ålesund and to live king crabs at Lerøy in Kjøllefjord. Furthermore, the instrument was used some weeks during the summer of 2025 in commercial tomato production for quality control of the sweetness. A key contribution this year was the continued maturation of SenseInside from a research prototype toward a pilot-ready system. Important work was carried out to gain a fundamental understanding of SenseInside relative to our well-established SmartSensor prototype, and how it behaves in real world environments, e.g. in varying temperatures. During his master's internship at SINTEF Digital, Bastian Krohg played a central role in this transition, contributing across software architecture, user interface design, embedded systems, deployment

Photo/cc: Marion O'Farrell, SINTEF

Marion (Pillar 1), Ellen (IAB), Vilde (PhD student) at BioTown 2025

Photo/cc: EPIC

Marion attending EPIC Annual Meeting

infrastructure, and hardware prototyping. His work significantly improved the usability, robustness and scalability of the platform and helped align related sensor platforms into a shared, maintainable ecosystem. The improvements were validated through field trials with researchers and industry partners, while also strengthening internal competence that can support the commercialisation of deep-tech sensor solutions.

OPPORTUNITIES

In 2025, the Opportunities activities focused on advancing promising research ideas toward concrete innovation projects and strengthening strategic collaborations at both national and European levels.

One activity was a targeted workshop series on non-contact core temperature measurements in food processing, organised together with Matbørsen, Lerøy and Nortura. The workshops addressed industrial needs related to food safety, quality control and process efficiency, and helped define requirements and application scenarios for contactless core temperature monitoring. We aim to secure additional funding for a new concept, called NIRCore, which is an AI-driven system for non-contact, inline, core temperature measurement in thermally processed foods. The innovation builds on SenseInside, a novel, sub-surface, near-infrared (NIR) sensor system, developed by SINTEF and Nofima.

In parallel, we conducted several technical and concept development workshops with the University of Lincoln and researchers in SINTEF, exploring a novel sensor concept which combines 3D shape measurement with spatially resolved physiochemical analysis for high precision robotics. The EU proposal was submitted in October 2025, representing an important step in expanding DigiFoods' activities within Horizon Europe and strengthening international collaboration in photonics-based sensing.

Marion and Vilde also attended Biotown 2025 which was hosted by Klosser Innovasjon, NCE Heidner Biocluster, AgriFoodTech Norway og Innlandet fylkeskommune. This is an important networking opportunity at a national level, with actors from technology providers and food producers in attendance.

Finally, we continued our work in support young researchers by setting up two summer internships, for Bastian Krogh, as an extension of his Masters, and Jonas Vistad. These were hosted at SINTEF as part of DigiFoods. These students worked across the FTIR, NIR, and MobileSense projects working on various prototypes – SenseInside, FragoPro and BumbleBee.

Pillar 2 Robot and sensor integration

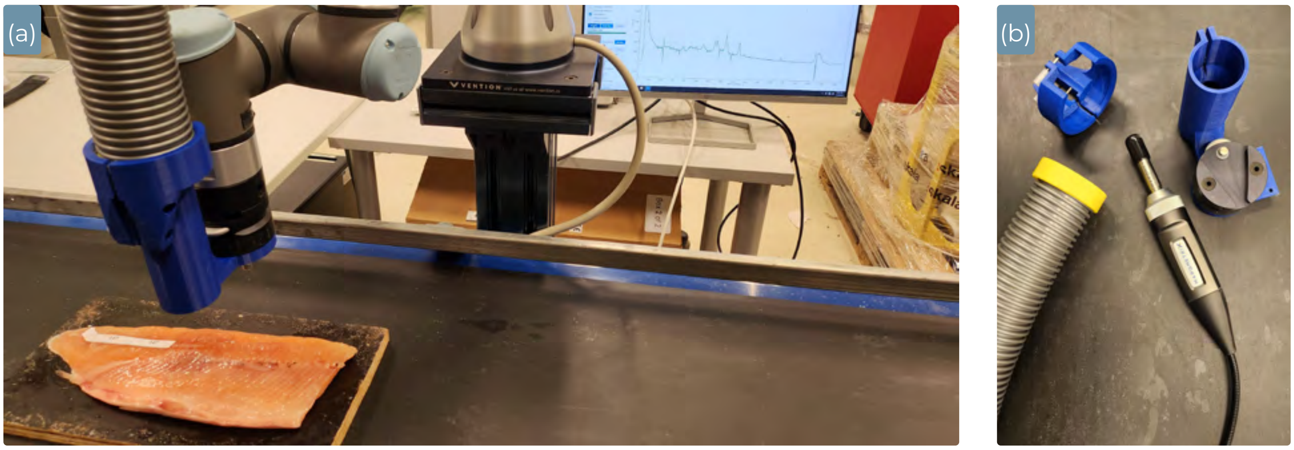
Robotics plays a strategic role in the transformation of the food sector toward greater sustainability, efficiency, and competitiveness. As food production systems face increasing pressure from labour shortages, resource constraints, and rising quality requirements, robotic technologies offer scalable solutions that enable smarter use of data, automation of critical tasks, and more robust production processes across the value chain.

Within DigiFoods, robotics serves as a key enabler that connects digital innovation with physical operations. Our work focuses on developing robotic solutions that can be deployed in real production environments—both in primary agriculture and in food processing—where flexibility, reliability, and ease of integration are essential. Rather than targeting isolated technical advances, we prioritise systems that address concrete industry needs and can be adopted by end users with minimal disruption to existing workflows.

A central ambition of our robotics activities is to improve how data is collected, interpreted, and acted upon in food production. By combining robotic platforms with advanced sensing and data-driven decision support, we enable more consistent quality control, earlier detection of deviations, and more efficient use of inputs such as labour, energy, and raw materials. This creates direct value for industry partners by reducing waste, increasing throughput, and supporting data-backed decision-making. Looking ahead, our strategic objectives include:

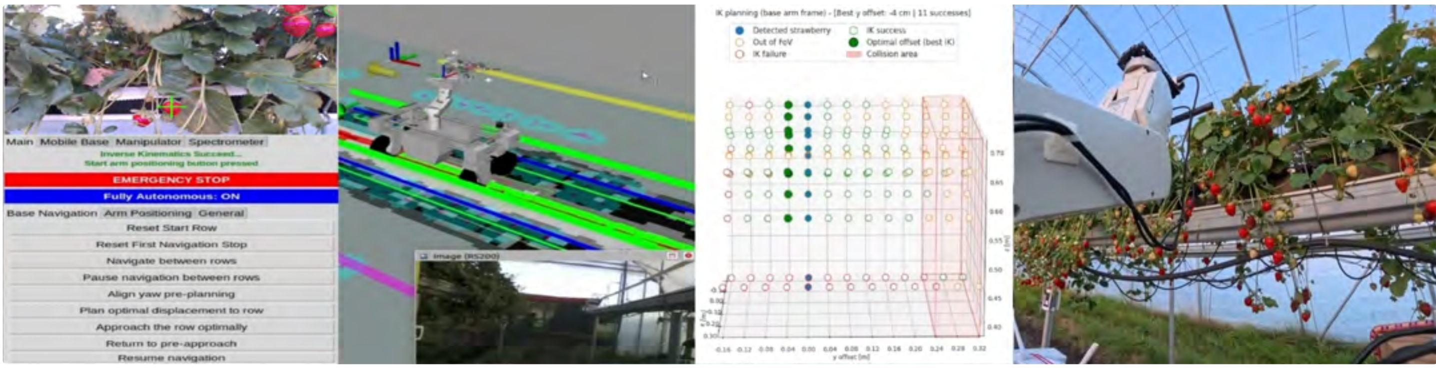
- Deployable autonomous and semi-autonomous robotic solutions for agricultural and food production environments
- Automated workflows that reduce manual handling and improve consistency and traceability
- Integrated systems that support real-time monitoring and rapid feedback to production processes

In the longer term, robotics will underpin new high-throughput analysis and monitoring capabilities, enabling faster and more cost-effective assessment of biological materials and food products. These developments are closely aligned with the center's broader research agenda and industrial collaborations, ensuring that robotic innovations contribute directly to commercialisation, knowledge transfer, and long-term impact in the food sector.



The overall in-line sensing system for food-processing environments enabled by a robotic solution:
(a) Raman sensor mounted on the 6–DOF UR3 robotic arm; (b) protective casing securing the Raman sensor.

Photos/cc: Michael Angelo Amith Fenelon, NMBU



Figure/cc: Gabriel Lins Tenorio , NMBU

Overview of the coordinated autonomous navigation and sensing system, showing the final remote GUI used to supervise and interact with the robot, the remote-monitoring visualiser, and the arm–base coordination planner visualisation used to optimise reachability and maximise data collection.

ROBOSENSE

ROBOSENSE enables the robotic operation of intelligent sensors in industrial food processing, providing accurate and efficient in-line measurements of key parameters in heterogeneous food products. The project aims to:

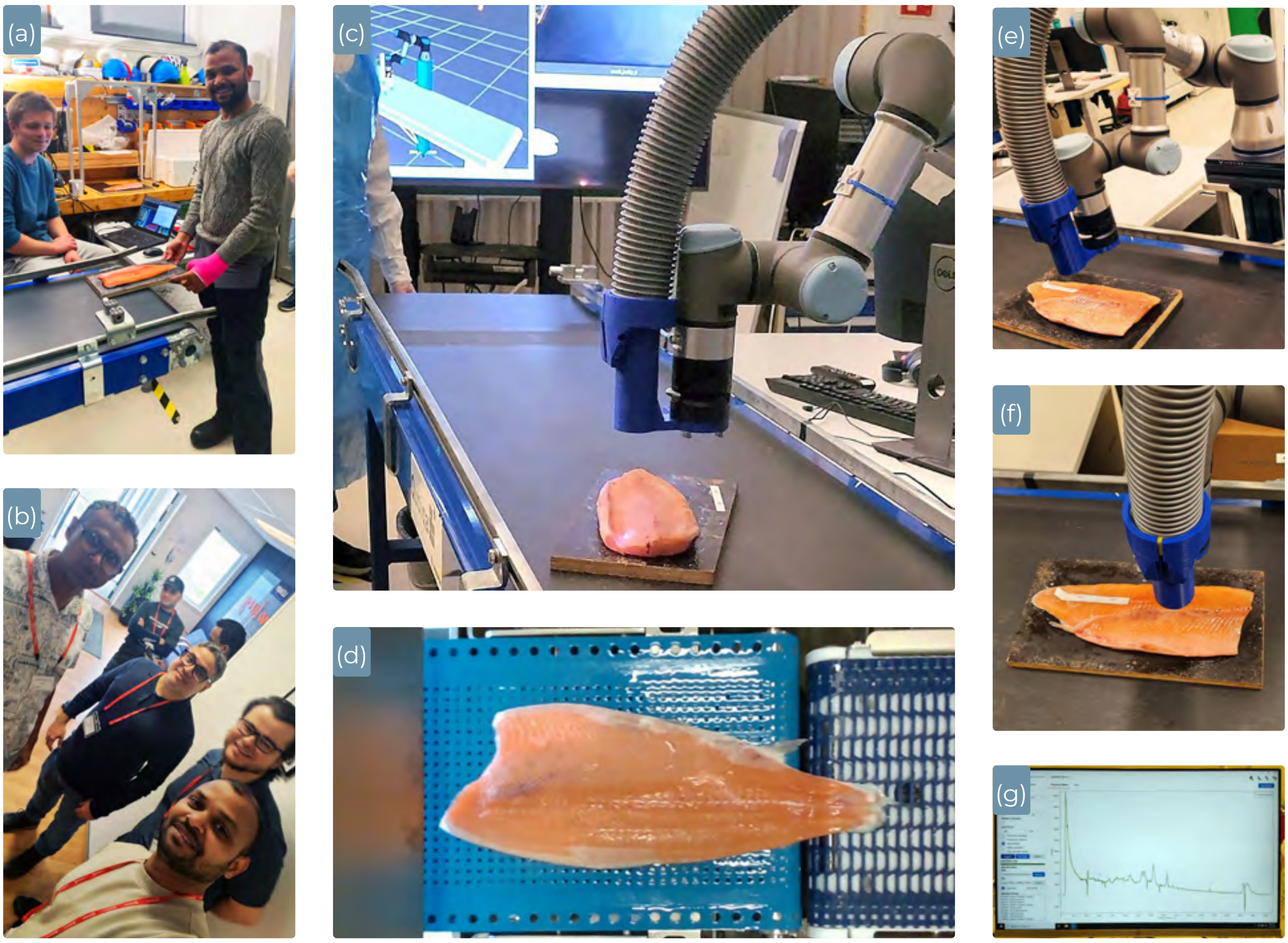
1. identify optimal methods for acquiring spectral measurements from specific regions of complex food samples moving along a conveyor belt;
2. develop an innovative and cost-effective approach for robotically controlled measurements, and
3. design and build a robotic prototype for testing under realistic conditions representative of a food-processing environment.

In 2025, the ROBOSENSE team conducted an experiment in the robotics lab at NMBU in Ås, using an autonomous robotic scanning setup (Figure above) to measure Omega–3 fatty acid content in approximately 80 salmon fillets. The experimental setup consists of a UR3 robotic arm equipped with an auto-triggered, all-in-one Raman sensor for in-line spectral acquisition. The technology was validated through systematic laboratory testing using a repeatable one-by-one scanning protocol, where each fillet was scanned individually and measurements were automatically repeated whenever signal quality fell below predefined criteria. This work was carried out under Pillar 2 of the ROBOSENSE project in close collaboration with RAMAN. The custom-built prototype system also includes an RGB-D camera, a GPU board, and a conveyor belt with an encoder to enable reliable, non-destructive quality assessment directly on the processing line. By integrating these cutting-edge technologies, we can analyse key nutritional parameters without interrupting production. Using this fully automated system, the ROBOSENSE team successfully measured and analysed the Omega–3 content of the scanned fillets, demonstrating repeatable performance in a laboratory setting. A scientific journal article is currently in preparation to report on the methodology and summarise the main findings from the laboratory trials.

Acknowledgements. We sincerely thank master's students Angie Alejandra Rozo Granados, Maciej Dobrowolski, and Jon Kastdalen for their valuable assistance during the experiments. We also thank Gareth Difford for providing the salmon fillets used in this study.

In parallel with the experimental activities, we developed a comprehensive salmon fillet dataset to support research on region detection, quality assessment, and nutrient analysis. Because the belly region of salmon is known to contain higher levels of omega–3 fatty acids, we applied computer vision and image processing techniques to identify the belly area and estimate fatty acid distribution across different trims (A, B, and C). For illustration,

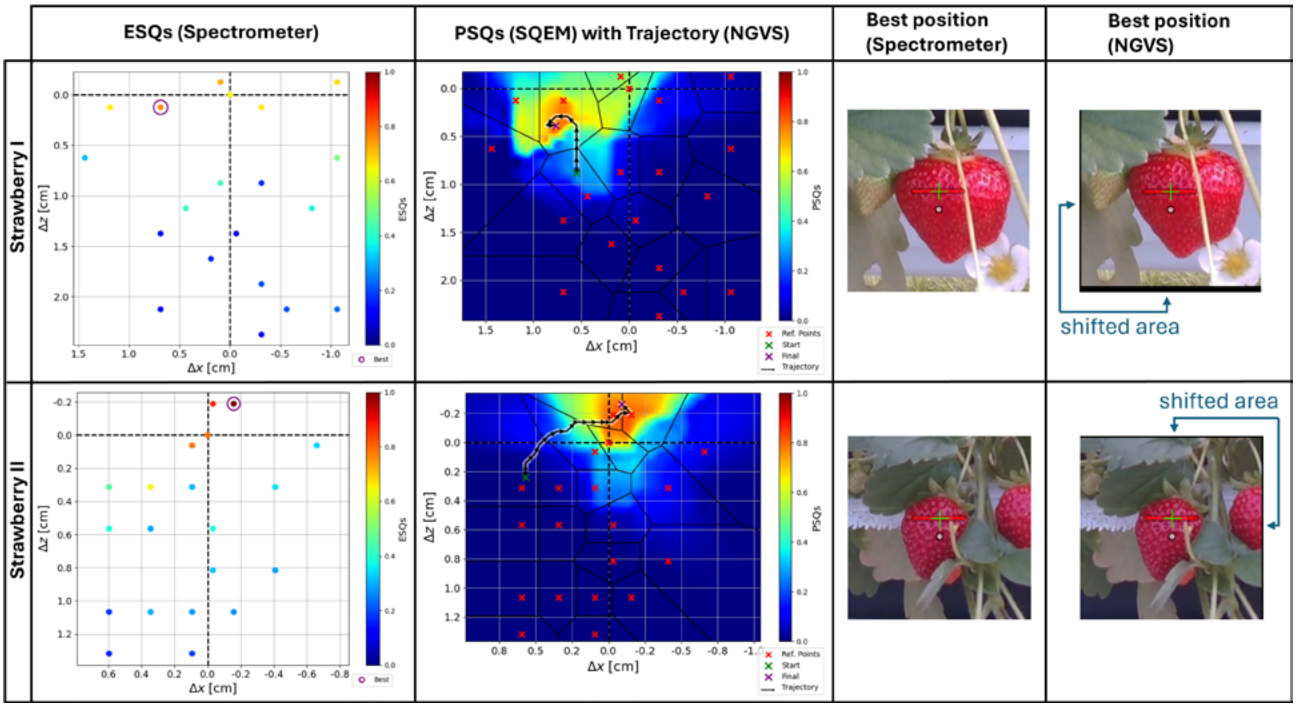
Figure 3d shows a representative image of a Trim A salmon fillet. The dataset includes RGB, RGB-D, and multispectral images collected both at the Lerøy Aurora processing plant in Skjervøy, Norway, and during controlled laboratory experiments at NMBU. Image acquisition was performed using Intel RealSense RGB-D cameras mounted in multiple configurations adapted to production-line constraints. In total, the dataset comprises more than 700 RGB images, several ROS bag recordings, and over 500 multispectral images. This resource provides a strong foundation for benchmarking, pre-training, and advancing automated salmon fillet analysis to enhance quality control and nutritional evaluation. The dataset is documented in a paper submitted to Data in Brief and is currently under review. Following publication, the dataset will be made openly available via DataverseNO (Dataverse Norway) to support further research and innovation in automated seafood processing. Alongside the laboratory work, ROBOSENSE was presented in the DigiFoods webinar series on 23 January 2025, in a talk titled *"Robots for Sensing in Agri-Food Value Chains: Current Progress in SFI DigiFoods and Future Directions"*. The project was also featured in an NMBU research news article (*"Robot sorterer laksen etter kvalitet"*, Georg Mathisen, 4 February 2025), highlighting its relevance for robust, compact sensing solutions in industrial fish-processing environments. These activities supported project dissemination and increased visibility among both research and industry audiences.



Photos/cc: Abhaya Pal Singh, NMBU

Overview of ROBOSENSE's latest activities: (a) NMBU master's students assisting with the experimental work; (b) the robotics group participating in the SFI DigiFoods annual meeting and visiting Lerøy Seafood in Lofoten; (c) the fully operational experimental setup used on real salmon fillets; (d) the robotic Raman scanning system used for effective measurement of fatty acid composition in salmon fillets; (e) a representative image of a Trim A salmon fillet; (f) a salmon fillet undergoing Raman measurement within the robotic scanning system; and (g) the resulting Raman spectra.

Figure/cc: Gabriel Lins Tenorio , NMBU



Data-driven evaluation comparing NGVS with the baseline method that positions the spectrometer at the experimentally ideal fruit location. For each strawberry, the NGVS trajectory and the resulting signal quality are shown, along with image pairs comparing the best measured view and the final NGVS position.

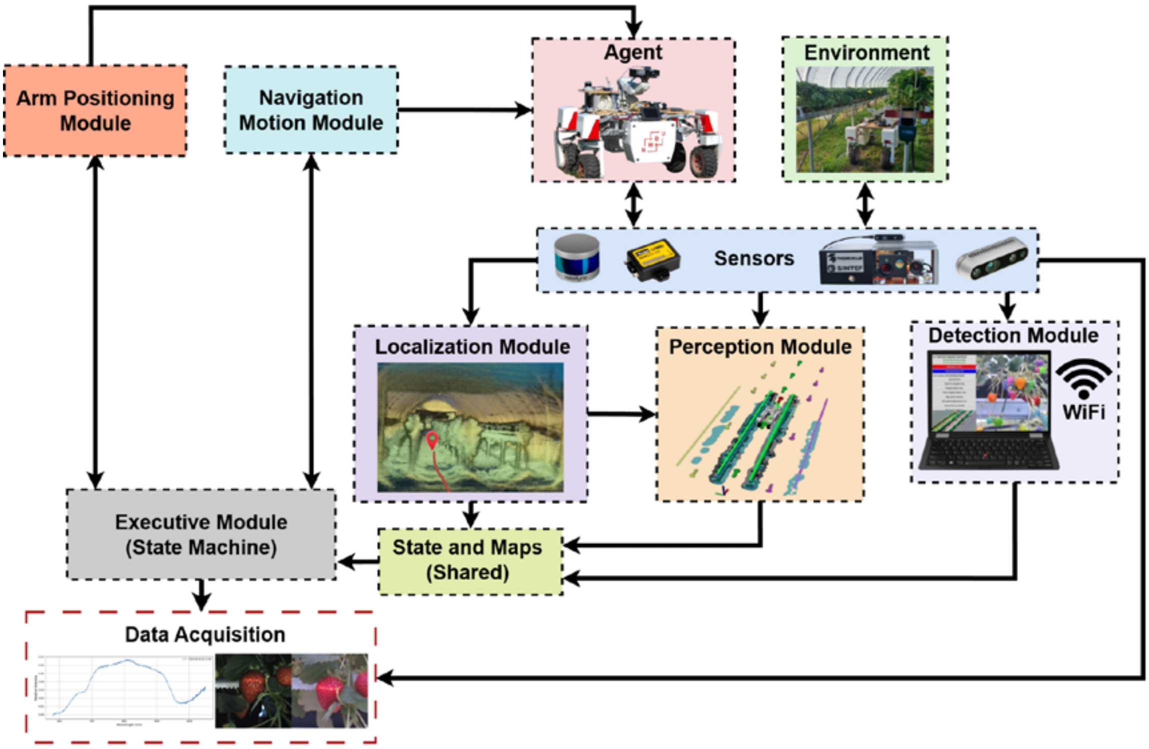
In 2026, the ROBOSENSE team will refine sensor calibration and feature-extraction methods to improve the accuracy and reliability of salmon fillet quality assessment and advance the project's Technology Readiness Level (TRL), with a strong focus on integrating the Omega–3 prediction models from RAMAN for automated sorting. We will also develop and validate a proof-of-concept digital twin of the robotic Raman system to simulate scanning strategies, robot motion, and AI-driven perception, while expanding and diversifying the dataset using virtual salmon fillets. Finally, we will design an intelligent feedback-control system to optimise robotic arm motion during scanning, ensuring high precision, repeatability, and safe handling of fillets on the conveyor line. We expect these developments to improve robustness and throughput, enabling reliable in-line prediction of Omega–3 and other quality parameters, and supporting automated sorting under representative conditions for the fish-processing industry.

MOBILESENSE

In MobileSense, we advanced the software capabilities of the designed mobile manipulator, enabling a deployment-ready integration between the Thorvald mobile base (Saga Robotics) and the Mitsubishi robotic arm for precise spectrometer positioning. The system relies on a RealSense stereo camera used for fruit detection and, to improve cost-efficiency, we replaced the previously used Ouster LiDAR with a Velodyne LiDAR and added an IMU to support SLAM-based localisation and reliable operation inside polytunnels. The overall system architecture has been designed around the integration of SINTEF's FragoPro sensor, targeting fully autonomous spectral data collection.

In 2025, we evaluated our novel visual servoing solution (NGVS), trained on synchronised spectrometer–robot data collected with FragoPro. We performed a data-driven evaluation indicating that the proposed approach achieves higher signal-quality consistency and a higher mean signal

Figure/cc: Gabriel Lins Tenorio , NMBU



System architecture of the MobileSense mobile manipulator, showing the state-machine module and the main modules for robot localisation, environment perception, remote fruit detection, robot movement, arm positioning, and data acquisition.

quality than the baseline method that positions the sensor at the fruit's experimentally ideal position. These findings will be included in our journal submission, targeted for early 2026.

Following the validation of autonomous sensor positioning, we implemented the planned autonomous navigation capabilities on the mobile platform. This work included real-time robot localisation in the tunnel, autonomous detection of crop rows, planning and navigation algorithms for structured movement between rows, and safety features to mitigate collision risks with people and other transient obstacles. In parallel, the graphical user interface (GUI) developed for experimental operation was expanded to support the autonomous data collection process, enabling remote monitoring, autonomous-mode control, and safe manual override during field deployments. Overall, the system architecture has been established, and the robot has been tested in the polytunnel environment across different terrain conditions and seasonal variability. Autonomy is orchestrated by a state machine that coordinates robot localisation, environment perception, fruit detection (remote workstation), robot movement and arm positioning, data acquisition and safety to execute the full sensing workflow. The state responsible for triggering data acquisition is already in place. This year, we will integrate this state with FragoPro to enable on-demand capture of synchronised spectral–robot data and validate this functionality in field deployments to complete the end-to-end autonomous data collection workflow.

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. Thus, strategies that address the practical and theoretical considerations for sensor implementation are clearly needed for the instruments that are already used commercially, but also for techniques for which we have very limited industrial experience, such as FTIR, Raman and fluorescence spectroscopy.

In Pillar 3 we are developing and validating efficient solutions and strategies for successful sensor implementation in food production. In other words: we are preparing sensors to actually work in the food companies. In DigiFoods, implemented sensors are also being used to explore and map variation in food processes over time. The sensors developed in DigiFoods are now providing previously unavailable information from food processes. This has for instance been shown for work at Hoff in 2023/2024, by industrial use of Raman and FTIR sensors in 2024, and in 2025 EXPLORATION has studied residues in eggshell membranes. Moreover, calibration robustness and calibration transfer are important aspects of all sensors developed in Pillar 1. In 2025 the new project TRANSFER has had focus on one part of this problem, namely from instrument to instrument

Pillar 3 is led by Dr. Nils Kristian Afseth at Nofima. For 2025, key partners in this Pillar have included food partners Nortura, Hoff and Norilia as well as Nofima.

We are preparing sensors to actually work in the food companies

TRANSFER

The project TRANSFER is in part a continuation of ROBUST yet with a narrowed-down scope to focus on tackling the calibration transfer problem of using an instrument calibration outside of the setting in which it was built. The classical example is going from one instrument to a new one – either the same type or of another. However, maintenance over time of an instrument deployed in the industry or when there are typically environmental differences when using a model in a new place may sometimes also be addressed using the similar tools.

In 2025, work in TRANSFER has addressed the classical calibration transfer problem: transfer of a model between instruments. We have chosen an approach which may help understand when and why methods work for this problem, and also to rank different methods as observed on our datasets. Given that the actual choice of dataset played such a strong role in performance of transfer, we have spent some time trying to clarify

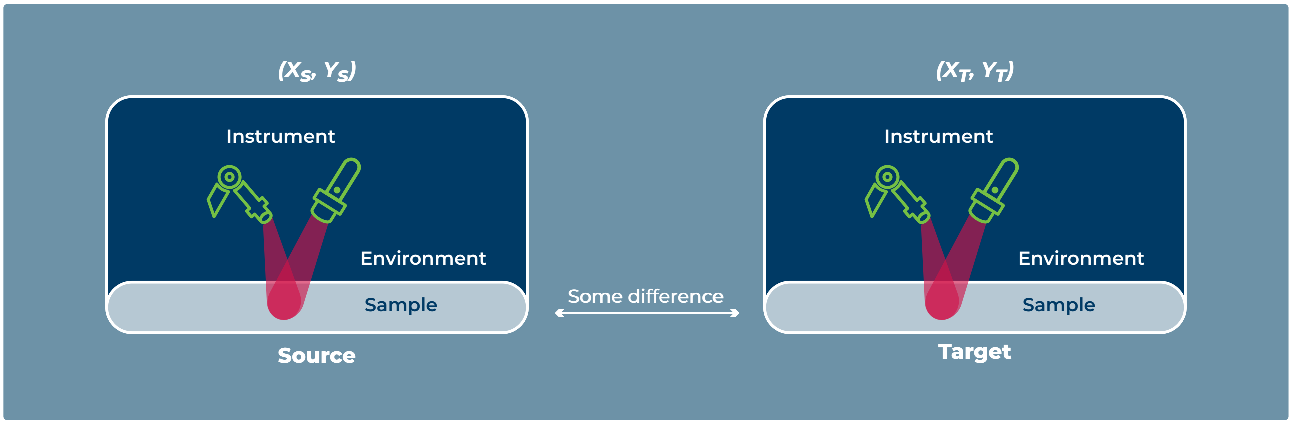


Illustration of the calibration transfer problems and which may depend on the instrument itself, differences in samples or in the environment. These differences need most often to be handled in order for a given model to remain valid in a new context.

what causes this dependency. Some of these results were presented at a conference in Iceland in June, and we plan to submit an article in the near future.

In 2026, work in TRANSFER will address other variations on the calibration transfer problem. The project will also seek collaborations with partners within DigiFoods to test findings and address issues.

EXPLORATION

A key challenge in many food processes is the missing knowledge about the actual quality variations. This information is crucial to gain insight into a given process to understand process behaviour over time. The knowledge about quality variation is usually based on sporadic or systematic measurements, maybe weekly or monthly. Process operators also possess valuable informal process knowledge based on personal experience and insight.

Photos/cc: Erik Tengstrand, Nofima

Equipment for separating eggshells and eggshell membranes.

Spectroscopic measurement of the eggshell membranes.

With smart sensors that measure and continuously monitor the critical quality features in a process, it is possible to document and map these variations along the processes and over time. The aim of EXPLORATION is to map exactly this variation and based on the results, figure out potential improvements, either in the final product or in the process itself.

In 2025, EXPLORATION has focused on measurements of eggshell residue in eggshell membranes. Norilia is currently separating eggshell membranes from the eggshells. In doing so, they can sell the eggshell membranes and reduce the waste that the eggshells otherwise represent.
By developing a fast spectroscopic method, the separation can be optimised, potentially further improving the sales of the membranes.
Trials have been made with a variety of spectrometers, with the SmartSensor having the most promising results due to the large sampling volume. Trials with sieving were also done, showing similar accuracy to the spectroscopic measurements.

In 2025, EXPLORATION has focused on measurements of eggshell residue in eggshell membranes

Pillar 4 Utilisation of large-scale quality assessments

In this Pillar, we develop data-driven solutions for process, product, and value chain optimisation. The solutions are based on extensive food quality measurements, combined with other relevant data sources from farm, industry, and consumer. The solutions are targeted at three application areas: Farming, food processing, and marketing.

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 stabilise 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 has had three projects in 2025; OPTIMISE, INSIGHT and CONSUMER. The CONSUMER project ends in 2025, and consumer-related activities will be integrated in a new project called VALUE in 2026.

Pillar 4 is led by Ingrid Måge at Nofima. Participating partners in 2025 were TINE, Nortura, HOFF, Lerøy Aurora, Maritech, Intelecy, NMBU and UPV.

Photo/cc: Ingrid Måge, Nofima

Nofima and NMBU presenting at the chemometrics conference in June at Keflavík, Iceland.

In-line monitoring systems based on spectroscopic sensors enable continuous measurement and real-time process adjustments, improving both quality control and operational efficiency

OPTIMISE

The objective of this project is to develop novel solutions that can be used to monitor, control and optimise food production processes in real time. The solutions will be based on statistical, machine learning or hybrid models, utilising both spectroscopic and other types of process data The food industry faces challenges in maintaining consistent product quality while making efficient use of raw materials. Traditional quality control relies heavily on offline laboratory testing, which is resource intensive, slow, and limits the number of samples that can be analysed. In contrast, in-line monitoring systems based on spectroscopic sensors enable continuous measurement and real-time process adjustments, improving both quality control and operational efficiency.

When spectroscopic data are combined with other process information, they become a powerful foundation for real-time process optimisation. In enzymatic hydrolysis at Norilia (Bioco) and Biomega, real-time measurements of raw material composition could allow dynamic adjustment of enzyme and water dosage to maintain a consistent molecular weight distribution in the protein hydrolysate. In HOFF's French fries production, in-line measurements of water content, together with temperature and humidity data, support finetuning of the drying step to achieve the desired dry matter content before frying.

For such systems to function reliably in industrial environments, they must be adaptive to changing conditions, incorporate relevant domain knowledge, and provide user friendly interfaces that support decision-making on the production floor.

In 2025, we initiated work on out of distribution (OOD) detection methods, which are techniques that identify when a model encounters data outside its training distribution and therefore cannot produce trustworthy predictions. These methods are essential for ensuring robust behaviour in real-time prediction models. We have surveyed available approaches and planned comparative testing using data from HOFF and potentially Bioco, with the goal of understanding how different OOD methods perform under real industrial conditions. This will be continued in 2026, including collaboration with Intelecy.

We also explored hybrid modeling approaches for the drying step in HOFF's French fries production. This work examined how basic physical principles governing water transport in air could be combined with data-driven models. However, progress has been paused due to insufficient data quality for temperature and humidity measurements, as well as modifications made to the dryer after data collection, which reduce the relevance of the existing dataset.

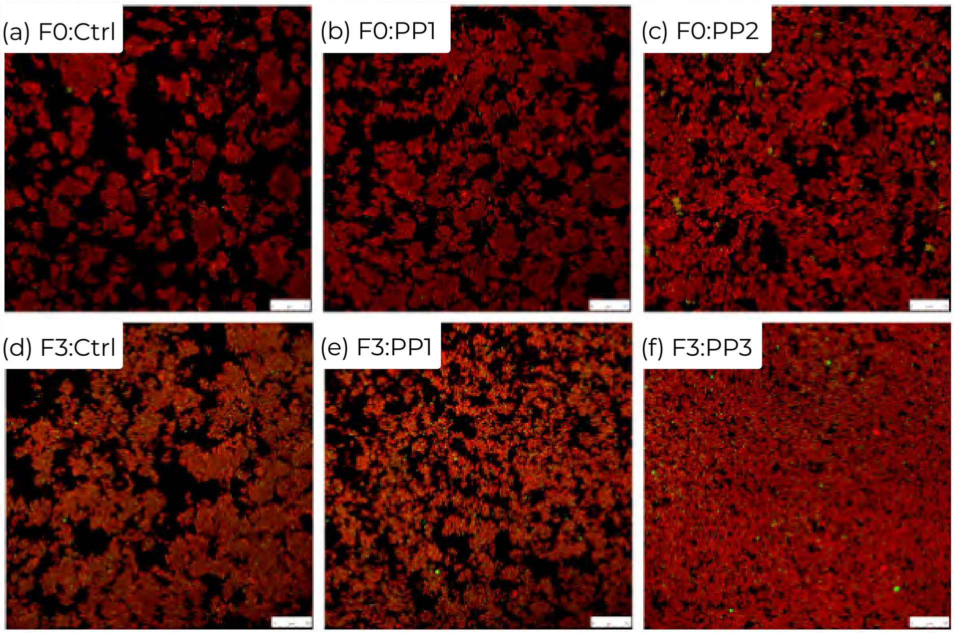
INSIGHT

The primary aim of this project is to develop innovative approaches for extracting actionable insights from industrial databases. By combining traditional analytical methods with advanced explainable AI and causal AI techniques, we seek to identify key drivers of variation in food production processes and quantify their effects.

Food companies routinely collect vast amounts of process and product data, and many data science initiatives aim to turn this information into practical improvements. Machine learning models that predict or classify production outcomes often play a central role. Interpreting these models can reveal new knowledge about products and processes: by analysing models trained on production data, we can pinpoint the variables that most strongly influence product quality and estimate the magnitude of their impact. Such insights can be directly translated into process improvements, for example by finetuning critical parameters, implementing targeted quality checks, or adjusting production protocols. TINE has already applied insights from earlier DigiFoods projects to identify key drivers of variation in cheese dry matter content, leading to permanent adjustments in vat temperature control systems.

This project builds on methods developed in the previous DigiFoods projects COMBINE and MODEL. In 2025, we investigated the “Retrospective DoE” algorithm developed by UPV, applying it to a case study of TINE’s cheese production process. The analysis confirmed earlier findings regarding the main drivers of variation, while also uncovering more subtle but consistent effects of controllable process parameters. The algorithm and results were presented at the annual meeting by Professor Albert Ferrer from UPV.

Work on causal modelling has also progressed through the PhD research of Christian B. H. Thorjussen, who is applying Directed Acyclic Graphs (DAGs) to a case study on chicken production with Nortura. DAGs are increasingly used to design statistical models for estimating causal effects. In a DAG, nodes represent measurable variables and arrows indicate hypothesised causal relationships, forming a structured representation of domain knowledge and prior research. Within this framework, testing conditional independence is essential for validating the proposed causal structure. In 2025, Christian released an R software package implementing a new computational method for testing conditional independencies across diverse data types. A corresponding software paper is in the final stages of publication in the journal *SoftwareX*.



CLSM-images of yoghurt samples with 0 wt% fat (F0) (a–c) and 3 wt% fat (F3) (d–f) after 9– weeks of storage. Ctrl = Control sample without post-processing 0W, PP1 = post-processing power 119W and PP2 = post-processing power level 296W. The protein is colored red, and the fat is colored green. Scale bar: 50 µm (Source: Food Quality and Preference)

CONSUMER

As consumers increasingly expect foods that are not only nutritious but also pleasurable, consistent, and trustworthy, the ability to measure and manage sensory quality becomes a powerful competitive asset. High-protein products, like yoghurts, are particularly sensitive to textural and flavour changes over time, and consumers quickly notice defects such as graininess, whey separation, or lack of smoothness. Research showing that targeted processing steps can maintain high sensory quality throughout extended storage, highlights a major opportunity for the food industry: quality data can become a strategic bridge between consumer expectations and product innovation. By understanding how consumers interpret texture, appearance, and freshness signals, companies can design products engineered to stay appealing longer, communicate shelf life more effectively, and reduce consumer driven food waste linked to perceived deterioration.

For DigiFoods, integrating sensory measurements, structural analyses, and consumer insights offers a way to not only improving products, but also strengthening consumer trust, guiding choice, and enhancing value across the entire food system.

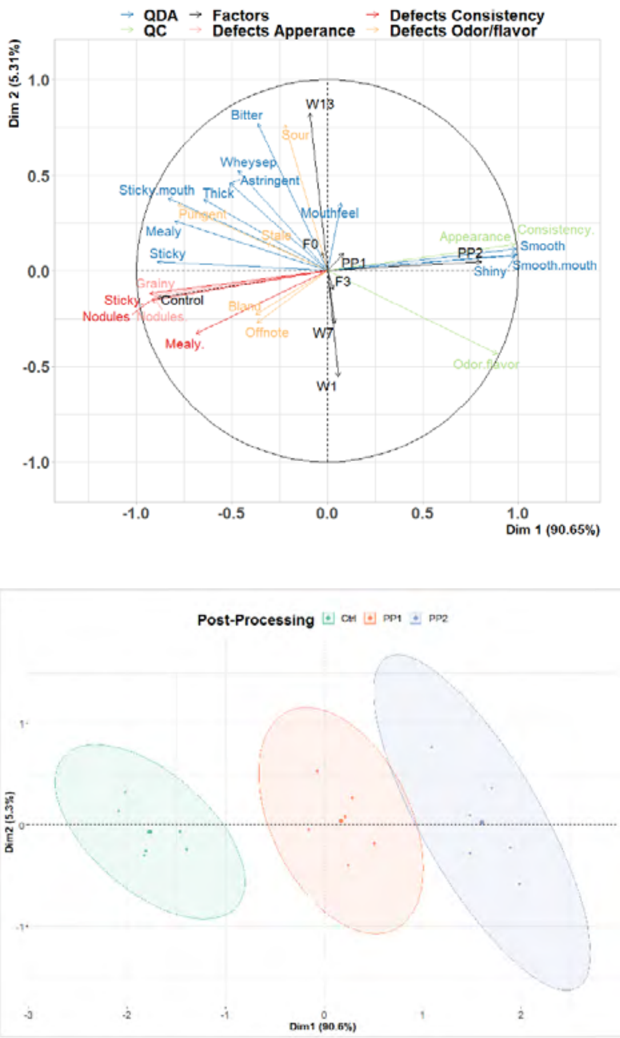
Case study with Tine

(Åse Riseng Grendstad's PhD)

Background: The study is motivated by industry challenges in producing high-protein yoghurts with good sensory quality. High-protein yoghurts (>5.6% protein) tend to develop grainy, coarse textures because of dense gel networks and insufficient structural breakdown during stirring. Previous research shows that different post-fermentation processing technologies (e.g., rotor/stator devices, ultrasound, shockwave reactors) can modify yoghurt structure, but little is known about how these treatments affect **sensory quality over storage time.** Since shelf-life in yoghurt is mainly limited by sensory changes — not microbiological safety — there is a need to understand how processing and fat content influence long-term texture, appearance, and flavour. Additionally, the study highlights the lack of research comparing **Quality Control (QC)** and **Quantitative Descriptive Analysis (QDA)** as sensory evaluation methods in this context.

Materials and Methods: This study investigated how post-fermentation processing using a rotor/stator device improves the quality of stirred high-protein yoghurts (6 wt% protein) with different fat contents (0% and 3%) during 13 weeks of storage.

Results: The study showed that applying rotor/stator post-fermentation processing at 119W or 296W significantly improved the sensory quality of high-protein yoghurt. It reduced whey separation, graininess, stickiness, thickness, and mealiness, while enhancing smoothness, shininess, and overall mouthfeel compared with untreated controls. Microscopy images showed that treated yoghurts developed a more continuous and finely structured protein network, whereas control samples exhibited large aggregates associated with sensory defects. These improvements were maintained throughout 13 weeks of storage, during which post-processed yoghurts consistently met industry quality standards, while control yoghurts were unacceptable from the start and remained so throughout storage. Fat content (0% vs 3%) played a secondary role, though higher fat yoghurts generally showed better texture stability and fewer defects over time. Overall, the authors conclude that post-fermentation processing is an effective tool to enhance and maintain the sensory quality and shelf life of high-protein yoghurts, and that quality control (QC) assessments correlate well with detailed sensory profiling (QDA), making QC a valuable, practical method for industry applications.



Multiple factor analysis with results from the QDA and the QC. Ctrl = post-processing power level 0W, PP1 = post-processing power level 119W, and PP2 = post-processing power level 296W. A) MFA correlation circle showing the relationship between QDA, QC and the factors (fat, post-processing, and storage time). W1=Storage week 1, W7= Storage week 7, W3= Storage week 13, F0 = 0 wt% fat, F3 = 3 wt% fat. B) MFA Score-plot, the clusters represent the post-processing power levels. (Source: Food Quality and Preference)

Graphs/cc: Åse Risberg Grendstad, TINE

• Photo/cc: Johanne Høie Kolås, NMBU

Bijay Kafle (right) and Mehmet Can Erdem (left) depositing samples into a silicon well plate to prepare dry films for protein analysis with a tunable laser-based high-throughput transmission measurement system.

5. International collaboration

DigiFoods has established close collaboration with three excellent foreign research groups and three foreign high-tech technology providers who are important for carrying out the research and innovation work. The research groups take active part in the running of projects and share supervision of PhD-students. It is an excellent base for exchange of PhDs and post-docs.

1. **University of Lincoln (ULin),** (UK), is represented in DigiFoods by Dr. Gregorz Cielniak and his research group at Lincoln Institute of Agri-food Technology. They are contributing 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 are taking active part in MOBILESENSE.
2. **Ulm University (UUlm),** (Germany), is represented by Professor Boris Mizaikoff, director of the Institute of Analytical and Bioanalytical Chemistry (IABC). UUlm has developed miniaturised mid-infrared sensing platforms based on thin-film semiconductor, oxide/nitride, and diamond waveguides that have already demonstrated their potential for analysing e.g., secondary structure changes in proteins. UUlm participates in the project IR and develops this platform further for in-line measurement of protein, lipid composition in foods and dairy and bioprocess control. Boris is also co-supervisor for PhDs and post-docs.
3. **The Polytechnic University of Valencia (UPV),** (Spain), is represented by Professor Alberto Ferrer, 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 participates in the INSIGHT and MODEL projects and provides joint supervision of PhD students and on data analysis and real-time process control.

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

4. **MarqMetrix,** (USA), now part of Thermos Fisher Scientific, provides modern, easy to use Raman instruments for rapid material analysis and process measurements. They are represented by Dr. Brian Marquardt, world leading in development of process Raman systems and very interested in novel food applications. He is contributing with knowledge and instrumentation in project RAMAN.
5. **nanoplus Gmbh,** (Germany), is represented by Dr. Johannes Koeth. They 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 online measurement of complex structures and composition in food samples online, such as fatty acid composition. This is being explored in the IR project.
6. **OptoPrecision GmbH,** (Germany), represented by Dr. Markus Naegele, is a leading company in research, development, and production of high-quality optical sensing devices and contributes by developing laser-driver and detection electronics in conjunction with the corresponding embedded software to realise a dedicated analyser platform in Pillar 1 and project IR. OptoPrecision left the consortium in 2025 because Marcus moved to another company, MEMS AG. MEMS has joined DigiFoods instead and will contribute to the same fields: Competence in IR instrumentation, Sensors for rapid gas composition determination that can be tested in relevant applications, and Participation in research activities.

Article

A sensor installed inside the pipe provides better answers about raw material quality

by Wenche Aale Hægermark, Nofima

When fish trimmings flow through the pipes at Biomega, lightmonitors the stream. Two light based measurement methods look directly into the flow of ground residual raw materials and reveal what it contains.

Photos/cc: Katinka Dankel, Nofima

Silje Steinsholm (Biomega) and Tiril Aurora Lintvedt (Nofima) at Biomega's factory on Sotra. In the background, salmon by-products are being hydrolysed and transformed into new ingredients.

The new measurement methods make it possible to monitor the quality of residual raw materials inside the process pipelines, giving Biomega better control of the fat and water content and enabling more consistent products from highly variable residual raw materials.

"Our aim is to develop a solution that gives better oversight of the quality of the incoming raw material. When we know the quality of the residual raw materials, we can adjust the process so that the final product is as similar as possible from batch to batch," says postdoctoral scientist Tiril Lintvedt at Nofima and DigiFoods.

Specially designed pipe section enables inline measurements

At Biomega's facility at Sotra, a straight pipe segment has been replaced with a specially designed section with two sensor probes mounted 50 centimetres apart. This distance was critical to ensure that light from the probes did not interfere with each other's measurements. One probe is connected to a NIR instrument and the other to a Raman instrument, and both send light into the stream of coarsely ground fish trimmings.

"What is new is that we can measure raw material quality directly in the pipeline as the materialflows past," says senior engineer Katinka Dankel at Nofima.

In earlier trials, NIR measurements were carried out at the grinder, which was impractical and difficult to keep clean. Now that the trimming mixture flows past the probes in a closed system, there is less mess and fewer disturbances.

"There was close collaboration between Biomega and Nofima throughout the process to identify the best solution. We had a good dialogue about what was important when installing the instruments in the pipe. Biomega drew the final design and ordered the new pipe section," explains Tiril Lintvedt.

Once the special pipe section was installed, staff at Biomega and Nofima had to find the optimal location for the parts of the instruments that are not in direct contact with the product. In fiber optic systems like this, the probe is mounted in the pipe, while optical fibers guide the light to the rest of the instrument, where the signals are read. At Biomega, the detectors were placed ten meters from the probes, a distance that could be much longer without compromising measurement quality. The solution was a wall mounted instrument cabinet with ventilation that keeps the temperature stable and prevents moisture ingress.

"One of our goals is that the pipe measurements will help us adjust the process in real time and achieve more stable operation. Whether this alone will deliver a more consistent final product is still uncertain, but it may become possible over time. A major advantage is that we obtain more reliable yield figures, even when the composition of the raw materials changes, particularly the water content. This provides better insight into how the process responds to different conditions, for example over the course of the year," says Biomega scientist Silje Steinsholm.

From laboratory trials to the processing line

Extensive preparatory work was required before measurements could start at Biomega. A key task was to develop calibrations – models that translate light signals into quantitative values for constituents such as fat and water.

"We placed the probe in a half pipe channel, a pipe cut lengthwise, to simulate measurements inside the process pipes in the laboratory. We received frozen, ground fractions and clean bone from Biomega, which we blended into different residual raw material mixtures," explains Lintvedt. "We slided the mixtures through the half pipe and measured them as the temperature increased from four to thirteen degrees. All spectra were included in the calibrations so that the models can recognise the variation occurring on the processing line."

She adds that the samples were first analysed with Raman and then with NIR, and that spectra at different temperatures were included in the models to capture the temperature variation that is typical at Biomega.

NIR and Raman offer different strengths

NIR (near infrared spectroscopy) and Raman spectroscopy are two spectroscopic techniques that both use light to analyse raw materials without destroying them.

NIR sends infrared light towards or through the raw material and measures how different wavelengths are absorbed, responding strongly to, among other things, water and fat. When the light hits the mixture in the pipe, some of it is reflected, and the pattern in the signal reflects the composition of the raw material. The method is rapid and well suited for continuous process monitoring.

Raman uses laser light to capture how molecules vibrate, and can provide detailed information about, for example, bones, proteins and fatty acid composition. The method delivers more detailed information than NIR, but it demands more advanced data processing and instrumentation.

"In this case, the highly variable material was challenging, but we have gained important knowledge for further development of Raman methods. Raman is little used in the food industry, so testing the technology on such a demanding raw material is an important step forward," Lintvedt points out.

The impact for Biomega

Biomega sources fish trimmings from several slaughterhouses, and the composition varies from delivery to delivery. Some batches contain more skin, and therefore more fat, while others have more bone or muscle. Such variation can cause unstable processing conditions and unpredictable final product quality. In the control room, operators monitor the process around the clock, tracking pressure, temperatures and a wide range of other process parameters.

With the new NIR sensor inside the pipes, operators gain valuable real time data and can follow the raw material mixture continuously as it moves through the system. NIR measurements enable operators to anticipate practical challenges and to diagnose problems that have already occurred. If the fat content is too high, for instance, the mixture quickly becomes thick and clay like. The measurements also open up opportunities to optimise the process: if the residual raw materials contain a lot of water, less water can be added later, and operators can adjust key parameters to achieve the best possible product characteristics.

Over four days, specialists from Nofima and Biomega worked together to measure the composition of the mixtures flowing through the pipes, collecting more than 1.7 million NIR spectra.

"The analyses show that the NIR instrument gives us a clear picture of how the composition changes from minute to minute, so we can see what is happening inside the pipes as it happens and adjust in time to secure more stable product quality," concludes Tiril Lintvedt.

Facts about the research

- The research and development have been carried out in the DigiFoods Centre for Research-based Innovation.
- The centre is led by Nofima, with SINTEF Smart Sensor Systems and NMBU (the Norwegian University of Life Sciences) as its main scientific partners.
- It is funded by the Research Council of Norway and the project partners, and aims to ensure better utilisation of raw materials, a healthier population and improved food experiences.

6. Recruitment, education and training

DigiFoods is planning to have a total of seven PhD fellowships and seven postdoctoral fellowships associated with our research over the lifetime of the centre. These candidates 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 of process data collected with sensors.

	Location	Candidate	Funding	Project	2020	2021	2022	2023	2024	2025	2026	2027	2028
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	Andreas U.N. Persch	RCN	IR									
	TINE (Nofima)	Åse Riseng Grendstad	TINE	CONSUMER									
	SINTEF/ Nofima	Vilde Vraalstad	RCN	NIR									
	NMBU	Mehmet Can Erdem	NMBU	IR									
Post-docs	Nofima	Samuel Ortega Sarmiento	Nofima	HYPERSPEC									
	Nofima	Rowan Romeyn	Nofima	HYPERSPEC									
	NMBU	Nageshvar Patel	RCN	IR									
	NMBU	Gabriel Lins Tenório	RCN	MOBILESENSE									
	NMBU	Abhaya Pal Singh	RCN	ROBOSENSE									
	Nofima	Tiril Aurora Lintvedt	Nofima	RAMAN									
	NMBU	Maren Anna Brandsrud	RCN	IR									

The potential for further relevant master thesis topics, for students finishing in 2026 and beyond, is high

At Nofima in Ås, Tiril Aurora Lintvedt defended her PhD work on in-line Raman spectroscopy aiming for representative sampling and modelling of heterogeneous foods in May 2023. She is now hired as a postdoc within the same field of research. Christian Thorjussen is developing statistical path modelling approaches, aiming at better understanding of factors and mechanisms causing variation in food quality. He will most likely defend his PhD in 2026. Marco Cattaldo, enrolled at Universitat Politècnica de València, is developing statistical methods for process and product optimisation based on real-time measurements of food quality and will also finalise in 2026. Bijay Kafle defended his PhD in 2024 for building and testing an FTIR prototype system for analysis of dried liquid samples, combining development of new applications with industrial testing of the FTIR prototype. He is now working as a researcher at NMBU on IR and FTIR technology, still with DigiFoods. Åse Riseng Grendstad started her PhD in 2022. She is funded by TINE and is working on consumer perceived quality of yoghurt as well as related spectroscopic properties. Vilde Vraalstad started her PhD work in September 2023 and is studying opportunities and limitations in the design of well working miniature NIR sensors for food applications where measurements in depth is essential. She sits at SINTEF and collaborates closely with Nofima.

At Nofima in Tromsø, both Samuel Ortega Sarmiento (2021) and Rowan Romeyn (2023) started as post-docs. They worked 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. They are now both in scientist positions at Nofima, still contributing to DigiFoods.

At NMBU, Mehmet Can Erdem, a member of the Biospectroscopy and Data Modeling (BioSpec) group, began his PhD in April 2023. He is focusing on the design and implementation of infrared optical devices and instrumentation. Dr. Bijay Kafle started a researcher position in DigiFoods at BioSpec in 2025, working on the applications of infrared devices for protein and fat profile measurements. Although the budget initially included a 2–year postdoc position, new regulations requiring a minimum of 3 years for postdoc positions led to his employment as a researcher instead. Dr. Maren Anna Brandsrud, co-funded by several projects, is working on waveguide sample interaction in the infrared spectrum for liquid sample measurements.

NMBU robotics attempted to hire a PhD in 2022 and 2023 to work on control of sensors to be used in complex measurements situations. It was very difficult to recruit PhDs within robotics, but we succeeded in hiring two postdocs in 2024. Gabriel Lins Tenório is focussing on how to operate sensors on mobile robots in the field. Abhaya Pal Singh develops robotic control of sensors at conveyor belts.

Bastian Krohg, master internship at SINTEF Digital in 2025, played a central role in advancing the SenseInside non-contact NIR spectroscopy platform from a research prototype toward a pilot-ready system. He contributed across all technical aspects of the development and significantly improved usability, robustness, and scalability, and was part of field trials with researchers and industry partners. In parallel, he developed a strong understanding of productisation and commercialisation, learning how technical design, user needs, and market considerations must be addressed together to move deep-tech solutions from laboratory research toward real-world adoption.

Article

FragoPro: The strawberry sweet sensor sensation

by Anders H. Hansen and Vilde Vraalstad

From field to landfill

An average Norwegian throws away some 85 kg of food every year. Nationwide, our food waste could fill sixteen thousand shipping containers. This number is clearly too high, and public awareness campaigns are seeking to bring it down.

However, consumer behaviour is only part of the puzzle. More than half of these 85 kg spoil before reaching the end user. Nudging consumer behaviour is therefore not enough: logistical improvements, such as better planning and forecasting, are needed to achieve real change.

Advanced sensors will play a central role in future food value chains. If crop ripeness can be measured — not only estimated — at harvest, if quality can be monitored from farm to fork, and if overripe or diseased individuals can be identified early, more food will reach the table before it goes bad.

Consider, for instance, Strawberries: a particularly challenging crop. They have a short ripeness window, are vulnerable to disease or damage, and are sensitive to weather. Unlike climacteric fruits such as bananas and avocados, strawberries cannot be ripened or warehoused after harvest. As a result, entire crates of strawberries are all too often discarded in grocery stores.

NIR perfection

Beauty, they say, is skin-deep. But a fruit's true quality — how sweet, juicy, firm, or bitter it is — lies beneath the surface. These things can be tricky to estimate, which is why traditional methods, like Brix measurements, require harvesting and destroying the fruit.

Saga Robotics entered DigiFoods with a challenge for the research partners: develop a sensor that can estimate strawberry quality directly on the plant and grade by ripeness. Such a sensor could help farmers manage their labour, optimise harvest time, maximise quality and shelf life, and provide yield forecasts for better logistics.

Sounds impossible? Near-infrared (NIR) spectroscopy offers a solution! It is a non-destructive, rapid "scanner" that can probe the inside of fruit without any sample preparation or contact. Infrared light penetrates the berry and carries information about its internal composition back to a sensor, revealing sweetness, acidity, and other quality traits — all without touching the fruit or cutting it open. This makes NIR ideal for on-the-plant assessment, rapid quality checks, and dense sampling across a crop.

SINTEF and Nofima had previously developed NIR instruments capable of measuring these internal qualities. In principle, the technology was right for the job, but the research prototypes were large, heavy, and not suitable for mounting on a field robot like Thorvald.

SINTEF faced a difficult miniaturisation challenge. Size, weight and power consumption all had to drop by an order of magnitude. New lens designs were needed to address aberration and light throughput. The mechanics had to be lightweight yet rigid to avoid optical distortions.

The result was **FragoPro** — a portmanteau of *fragola* (strawberry) and *GoPro*. FragoPro is a multi-modal sensor that combines in-depth NIR spectroscopy with visual imaging. It measures both external features like colour, size, and visible defects, and internal properties such as sweetness and bitterness. Its onboard computer and WiFi connectivity enable rapid data processing and live transmission to the farm office.

Strawberry fieldwork forever

During the 2021–2023 harvest seasons, FragoPro technology was tested in the laboratory and in NMBU's strawberry field. While NIR works reliably indoors, operating the instrument outdoors in sunlight proved far more challenging. The probe light returning from the berries is weak and easily overwhelmed. The result was unreliable NIR measurements, including clearly absurd results like negative optical intensity or sugar content above 100 %. It was clear that FragoPro needed additional innovations.

In the lab, we measure each sample twice, with the probe light on and off, and take the difference. This allows the probe light to be isolated, but it requires that the background light remains stable. In the field, as sunlight fluctuates due to clouds and moving shadows, lighting can change from second to second. To make things worse, sunlight carries photon shot noise (an unavoidable consequence of the quantum nature of light), which may obscure the measurements.

To combat this, a new, high-speed shutter was installed, allowing the instrument to run measurement cycles faster than fluctuations in sunlight. The spectrometer was configured to avoid saturation in harsh sunlight. And measurement sequences were extended to include many shutter cycles to improve data quality.

Additionally, our data processing strategy needed an overhaul. New methods were developed to more accurately isolate strawberry signal from background. And simple quality metrics were introduced to identify and discard unreliable measurements, prompting the operator to re-take until quality is acceptable.

With this improved system in place, we returned to the field to test the sensor in realistic and demanding conditions. On a sunny August day in 2024, 100 strawberries were selected and measured repeatedly over a 24–hour period, while still on the plant. We measured in strong midday sun, in the afternoon, at night, and in indirect morning light. The berries were then harvested and brought to the laboratory for controlled measurements and reference measurements of sugar content.

After this test campaign, a multivariate calibration model, based on a separate training set of berries, was stress-tested on the challenging field data.

Sweet sensing in the sun

With the combination of better hardware and improved data analysis, we succeeded in removing sun-light contamination from the NIR measurements, even under challenging outdoor conditions. As a result, FragoPro obtained accurate sugar measurements, even in strong midday sunlight. Each berry was probed for 12 seconds. While this may sound long, it is much faster than the alternative: Brix measurements, which require destructive sampling of a few berries, leaving the majority of the crop unmeasured.

These experiments provided a detailed picture of the challenges in the field, revealing how sunlight and other disturbances affect measurements. Rather than relying on complex data analysis to compensate, we focused on understanding the underlying physics. This knowledge guided the optimisation of instrument design, sampling strategy, and signal processing, making the instrument robust under real-world conditions.

In the NIR future...

Together, these advances transformed FragoPro from a laboratory instrument into a robust field sensor, capable of extracting meaningful sweetness measurements of berries even under the ever-changing light of an open sky. This enables non-destructive quality measurements directly on the plant, opening the door to entirely new ways of monitoring crop quality.

Looking ahead, the knowledge and technological innovations of FragoPro are being carried forward to its sibling instrument, SenseInside, applying the same NIR principles to new domains both within and beyond the food sector.

FragoPro itself will continue to serve as a research instrument, combining NIR spectra with visual colour images. In doing so, it supports further exploration of non-destructive quality measurements and contributes to the development of smarter, more sustainable food systems.

Photos/cc: Vilde Vraalstad, SINTEF

Anders Hansen (SINTEF) measuring strawberries in the polytunnel at night.

7. Communication and dissemination

The primary objective of DigiFoods is to develop smart sensor solutions for food quality assessment directly in the processing lines, throughout the food value chains. The obtained food quality information will be used for optimisation of both processes and value chains and make the food industry more efficient and sustainable.

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

Our priority target groups are:

- Industry: Food and bioindustry, technology companies
- Scientific community: scientist and students
- The Public, including funding bodies and policymakers

Dissemination within the project

One newsletter (in June) has been produced and distributed via e-mails to the partners and funders.

The annual meeting took place in Svolvær in Lofoten with an organised tour to Lerøy Seafood in Stamsund to learn about fish cake production. In addition, results were disseminated and needs and challenges discussed. 53 persons from the different partner

Photo/cc: Lars Erik Solberg, Nofima

DigiFoods visited Lerøy Norway Seafoods' fish cake factory at Stamsund during the Annual meeting in May.

DigiFoods was well represented at the International Conference of NIR Spectroscopy in Rome.


forskning.no

Disse sensorene vet hvor søte tomatene er

Ny målemetode kan gi saftigere og tryggere fiskekaker

Faksimiler

External communication and dissemination

During 2025 the media outreach in DigiFoods has resulted in 42 news articles in the press. 34 of these where in the Norwegian press, both trade magazines like *Bondebladet, Gartneryrket, Smaksmagasinet* and *Kystmagasinet*, and more public media such as *NRK EKKO* and *Forskning.no*. All international articles were in English.

In addition, results from DigiFoods were presented at the fairtrade UMAMI in March, at Arendalsuka and at SmartFarming at NMBU in August. A demonstration of the instrument SenseInside was made for the Norwegian salted and dried cod industry, the clipfish industry, in November.

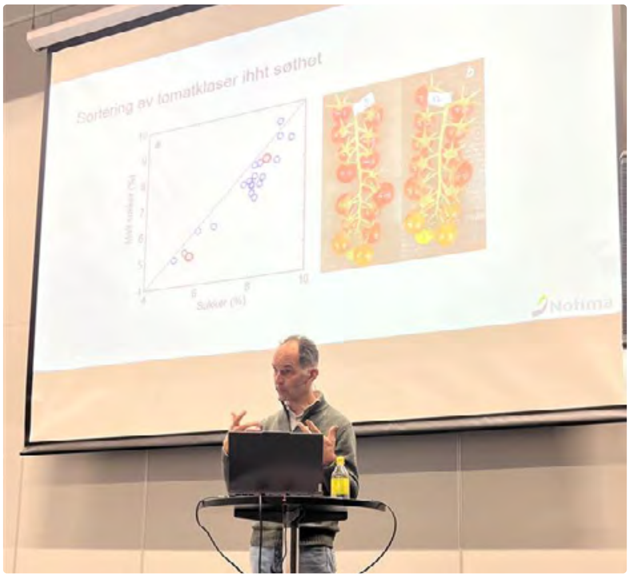
Scientists and students also held more than 15 presentations in Europe and the USA, sharing insight and results from the centre, as well as hosting events for relevant scientific communities and the industry.

As examples we can mention the International NIR conference in Rome were DigiFoods was well presented with two lectures (Vilde Vraalstad and Jens Petter Wold), one poster (Erik Tengstrand), the two companies NEO (Lars Gidskehaug) and Prediktera (Andreas Vidman) as well as our board member from NMBU, Ingunn Burud.

Achim Kohler was invited as key note speaker at the senseAIfoods conference in Tirana. We were also a group attending the Scandinavian Symposium on Chemometrics in Keflavik.

42 news articles in the press
↓
34 of these in the Norwegian press

15+ presentations held in Europe and the USA



Photo/cc: Wenche Aale Hægermark, Nofima

Centre Director Jens Petter Wold presenting to the food industry at the UMAMI arena

Article

When Food Meets AI

by Wenche Aale Hægermark, Nofima

Food factories generate enormous volumes of data every day. Sensors track temperature, humidity, chemical composition and dozens of other variables in real time. Yet turning that data into smarter decisions remains a major challenge. This is where the collaboration between technology company Intelecy and food science institute Nofima, through DigiFoods, creates impact for both sides and for the food industry.

Intelecy joined DigiFoods as an industrial partner, contributing a no-code AI platform that enables process engineers and operators to build and use machine learning models with just a few clicks, no coding required.

“Today, factories often have thousands of sensors, generating vast amounts of data, but without the right tools to quickly turn it into actionable insights, operators become overwhelmed and critical information is missed” says Program Manager Vegard Søberg at Intelecy.

A stronger toolkit through collaboration

Intelecy’s platform connects to real-time sensors in factories and combines it with other data like laboratory measurements when needed. It helps operators detect irregularities, look ahead and support decisions in daily operations. Nofima scientists contribute with deep knowledge of measurement methods such as NIR- (near-infrared) spectroscopy and data analysis. Intelecy, in turn, contributes industrial machine learning competence and a practical layer that makes models and algorithms easy to use in production.

“Industry needs tools that allow them to do their own analyses, and that’s exactly what Intelecy’s software provides. In our research group, we compare a wide range of machine learning methods to identify the most robust approaches, and we also develop algorithms further when needed. Intelecy adds their own layer on top of complex machine learning algorithms, so that operators can use them to monitor and optimise their processes without any coding experience,” says senior scientist Ingrid Måge at Nofima.

Controlling the water content in protein powder

A concrete example of this two-way impact comes from TINE's dairy plant at Jæren, where they produce both cheese and whey protein concentrate used in sports nutrition. During the first DigiFoods period, Intelecy and Nofima collaborated on improving the cheese production process. Nofima assisted in setting up an NIR instrument that now streams data directly into the Intelecy software, enabling TINE to gain new insights and optimise the cheese production.

Photos/cc: Intelecy

Intelecy visiting the TINE dairy factory at Jæren.

We have now moved on to working with the whey protein production process. Maintaining the right moisture content in the whey protein powder is critical. Too much water reduces product quality, while excessive drying increases energy use and production costs. For TINE, even small deviations can have noticeable impact.

Intelecy has already analysed data from this process to identify which parameters influence moisture variation the most. Their analysis showed that the exhaust air humidity in the dryer is a key factor. Based on this insight, TINE has used the Intelecy platform to implement a machine learning model that predicts exhaust air humidity, giving operators early warnings when the process begins to drift.

"Our collaboration with Intelecy has given us deeper insight into the factors that influence the water content in our WPC production," says Magne Aase, Production Improvement Production Improvement Manager at TINE Jæren.

The analysis also revealed that a significant part of the variation cannot be explained with the instruments currently in use. As a result, TINE is currently planning to install a NIR sensor to monitor the water content in the powder. Nofima and Intelecy will collaborate on exploring how these new measurements can be used to further improve the process.

Causal models: same method, different perspectives

The second example shows how one method can be used in different ways. Within DigiFoods, PhD scientist Christian Thorjussen at Nofima has developed a method and an open-source R software package called CCI (Computational Test for Conditional Independence). This tool helps scientists judge whether cause-and-effect relationships in a system are consistent with observed data.

"We use this method in a theory-driven way. In collaboration with Nortura we have studied if different types of growth feed influence the prevalence of a heart condition called ascites in broiler chickens. To do this, we begin with established biological knowledge about chicken growth and then use data to test whether the assumed causal structure holds", explains Måge.

Intelecy is also interested in causality, but from a different angle. Instead of starting with a pre-defined theory, they want to discover unknown causal relationships directly from data. This is called *causal discovery.*

"The goal is to map every meaningful connection inside a processing facility, which variables influence which outcomes and how, says Søberg.

Tackling the hard, high-value problems together

A joint workshop between Nofima and Intelecy helped clarify where collaboration creates the most impact.

"We can handle the "low-hanging fruits" directly, such as relatively simple optimisation tasks that are clearly defined and easy to implement. The most interesting common ground lies in problems that are demanding to solve, but have high value when they succeed," says Remi Goget, SVP Technical Sales & Customer Success at Intelecy.

He continues: "The workshop showed that we can complement each other, especially in complex cases where the value is large if we solve the problem".

Value engineering workshops with DigiFoods partners help identify such cases by mapping which problems are valuable, feasible and visible for the wider organisation.

From insight to daily practice

The partnership within DigiFoods demonstrates a principle that goes beyond any single project. Intelecy learns about spectroscopic measurement methods and gains insight into food processes. Scientists gain access to a scalable AI platform and increases the possibility that their research reaches factory floors faster. For food companies, this means more targeted use of data to stabilise quality, reduce waste and explore new ways of running their processes.

DigiFoods provides the arena where these connections form. However, as Ingrid Måge points out: "It is crucial that companies are willing to share data and enter an open dialogue about their challenges. When scientists, technologists and industry meet in that way, new solutions become possible"

Publication and dissemination

Peer-reviewed publications

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Kohler, A. (2025). Data augmentation in physics- and chemistry-aware data modelling in vibrational spectroscopy. senseAIfood conference, 08.–10.10.2025, Tirana, Albania.

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Thesis

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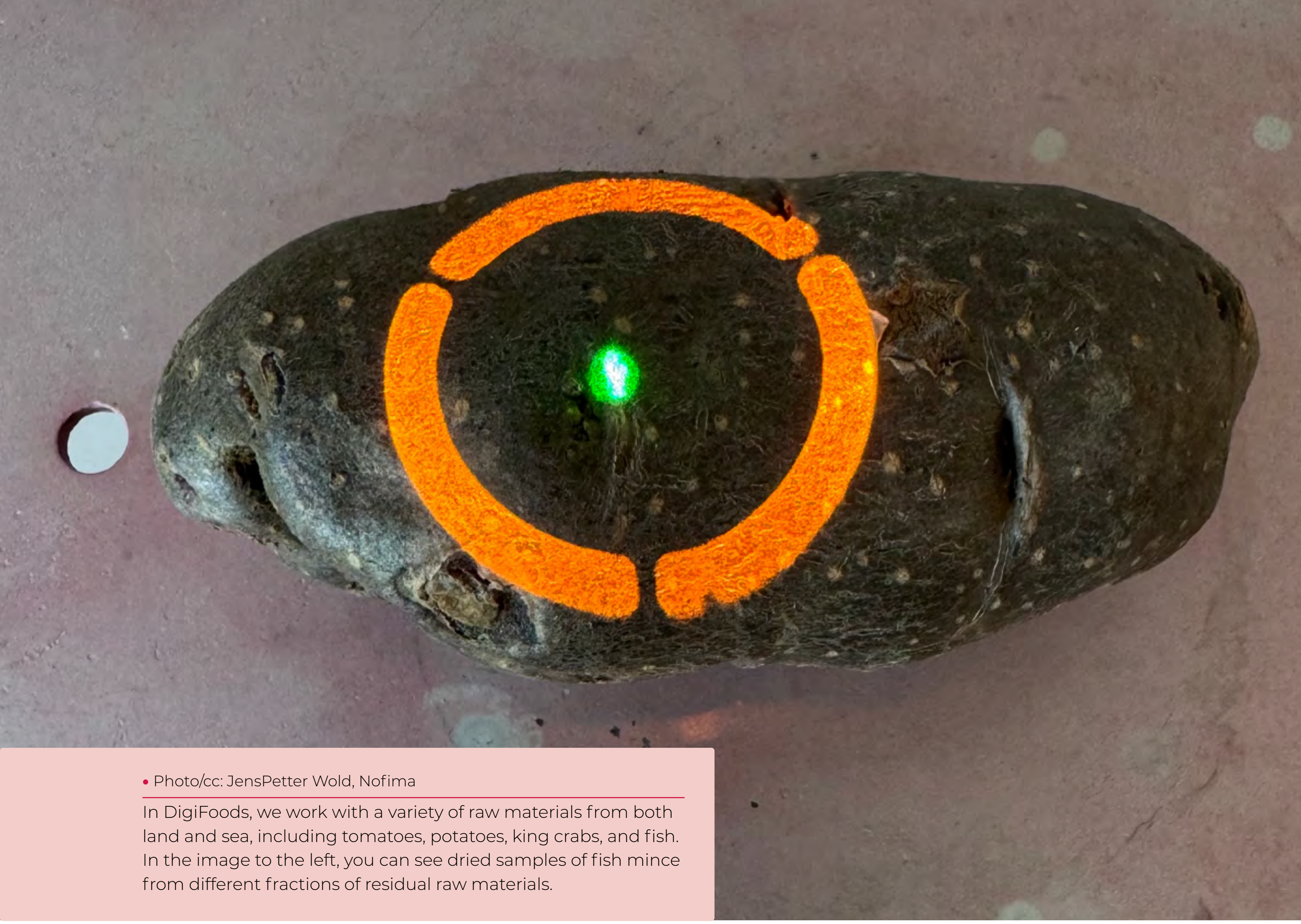
Photo/cc: JensPetter Wold, Nofima

Photo/cc: Wiig Gartneri



• Photo/cc: JensPetter Wold, Nofima

In DigiFoods, we work with a variety of raw materials from both land and sea, including tomatoes, potatoes, king crabs, and fish. In the image to the left, you can see dried samples of fish mince from different fractions of residual raw materials.

• Photo/cc: Jon Tschudi, SINTEF

8. Administration

Key personnel

Postdoctoral researchers with financial support from the Centre budget

Name	Period	Topic
Rowan Romeyn *	2023–2024	Hyperspectral imaging for food analysis
Gabriel Lins Tenorio	2024–2027	Synchronized Navigation and Manipulation
Abhaya Pal Singh	2024–2026	Integration of sensors with robotics
Tiril Aurora Lintvedt	2023–2026	Applied Raman spectroscopy
Maren Anna Brandsrud	2025–2026	IR Instrumentation
Bijay Kafle	2025–2026	IR and FTIR technology

* Romeyn was hired as a Researcher in Nofima in August 2024

PhD students with financial support from the Centre budget

Name	Period	Topic
Bijay Kafle	2021–2024	Dry-film FTIR spectroscopy for in-process food quality measurements.
Mehmet Can Erdem	2023–2027	IR instrumentation
Tiril Aurora Lintvedt	2020–2023	Raman spectroscopy for in-line food quality sensing
Christian Thorjussen	2021–2024	Path modelling in agriculture and food industry
Marco Cattaldo	2021–2024	Data fusion and process optimization/control
Vilde Vraalstad	2023–2026	Fundamentals of applied NIR spectral measurement solutions

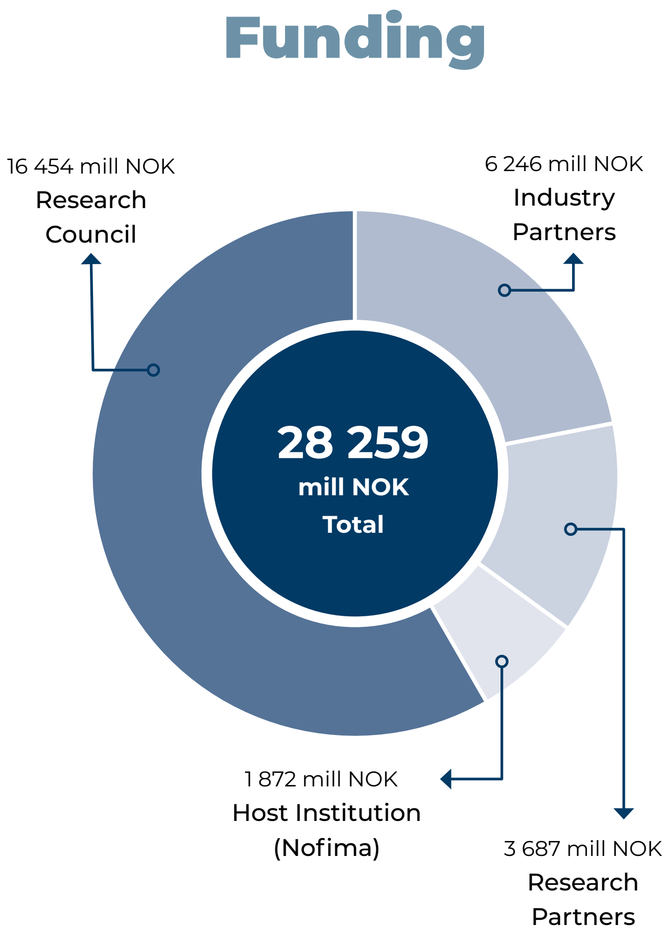
PhD students with financial support from other sources

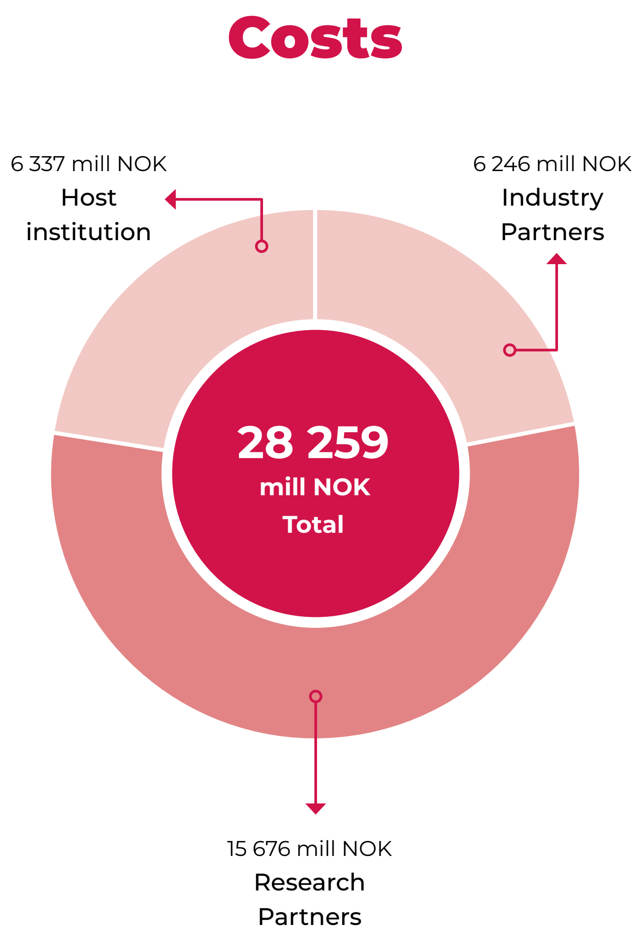
Name	Funding	Period	Topic
Åse Riseng Grendestad	TINE	2022–2026	NIR & Consumer studies

Key researchers

Name	Institution	Pillar	Main research area
Jens Petter Wold	Nofima	1,2,3	Applied spectroscopy and food science
Karsten Heia	Nofima	1	Applied spectroscopy
Kate Anderssen	Nofima	1	Applied spectroscopy
Petter Andersen	Nofima	1	Applied spectroscopy and food science
Rowan Romeyn	Nofima	1	Hyperspectral imaging applied to food quality analysis
Samuel Ortega	Nofima	1	Hyperspectral imaging applied to food quality analysis
Sileshi Gizachew Wubshet	Nofima	1	Analytical chemistry
Nils Kristian Afseth	Nofima	1,3	Applied spectroscopy and chemistry
Erik Tengstrand	Nofima	3	Applied spectroscopy and chemometrics
Lars Erik Solberg	Nofima	3,4	Data analysis
Ingrid Måge	Nofima	4	Multivariate data analysis
Paula Varela	Nofima	4	Sensory and consumer science
Valérie Lengard Almli	Nofima	4	Sensory and consumer science
Achim Kohler	NMBU	1	Applied spectroscopy and physics
Bijay Kafle	NMBU	1	IR Instrumentation
Boris Zimmermann	NMBU	1	Applied spectroscopy and chemistry
Volha Shapaval	NMBU	1	Spectroscopy and biotechnology
Antonio Candea Leite	NMBU	2	Robotics
Nils Bjugstad	NMBU	2	Agricultural technology
Weria Khaksar	NMBU	2	Robotics
Kristian Hovde Liland	NMBU	4	Data analysis
Kari Anne Hestnes Bakke	SINTEF	1	Optical measurement systems and smart sensor systems
Trine Kirkhus	SINTEF	1	Optical measurement systems and smart sensor systems
Anders Hansen	SINTEF	1,2	Optical measurement systems and smart sensor systems
Gregory Bouquet	SINTEF	1,2	Optical measurement systems and smart sensor systems
Jon Tschudi	SINTEF	1,2	Optical measurement systems and smart sensor systems
Marion O`Farrell	SINTEF	1,2	Optical measurement systems and smart sensor systems
Simon Pearson	Uni. Lincoln	2	Agricultural robotics
Grzegorz Cielniak	Uni. Lincoln	2	Agricultural robotics
Boris Mizaikoff	Uni. Ulm	1	IR spectroscopy
Alberto J. Ferrer-Riquelme	Uni. Valencia	4	Process modelling and control

Annual accounts





Photo/cc: Anne Risbråthe, Nofima

The DigiFoods consortium gathered for the 2025 Annual meeting in Svolvær.

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

Norwegian Centre
for Research-based
Innovation