AARHUS UNIVERSITY

PERSPECTIVE

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DCA – DANISH CENTRE FOR FOOD AND AGRICULTURE

Food and agricultural sciences
Research-based policy support
Knowledge exchange and industrial collaboration
National and international research alliances

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Cover photo
Mario M. Martinez carries out research in chemo-mechanical methods to turn stale bread into biodegradable materials (page 42) as well as the interactions between plant cell walls and flavonoids (page 47).

European cooperation on research-based policy advice

Exchange of experience of research-based policy advice within agriculture and environment will contribute to the green transition in Europe.

The green transition has a high priority on the political agenda – and not only in Denmark. All European countries join efforts to reduce emissions of greenhouse gases, nutrients, pesticides, and other xenobiotics. Within the framework of the EU, a green deal as well as a Farm2Fork strategy have been adopted, preparing the ground for significant changes in agricultural and food production.

Climate change, environmental impact and degradation of biodiversity constitute long-term threats to mankind, and there is a huge global wish to act.

Society – companies, farmers, organizations, authorities, and citizens/consumers – all have a common task in ensuring the implementation of the green transition. The authorities are responsible for establishing e.g., legislation and framework conditions ensuring the necessary transition. This may prove complicated as sustainable solutions may depend on fundamental changes in both agriculture, food production, resource management as well as the lifestyle of individual citizens.

Initiatives to promote the green transition may be difficult to accomplish. In the social debate arguments are that unilateral Danish reductions will simply mean exporting the problems, resulting in an increase in the total global climate impact. Contrary to this, another argument emphasizes that it is a competitive parameter to produce food with a reduced climate and environmental impact and, at the same time, consider animal welfare.

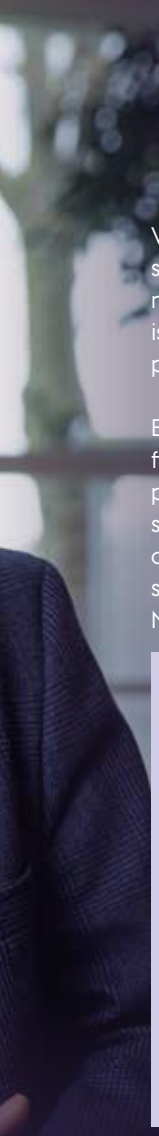
Other voices express concern as to supply problems and increasing food prices (sadly actualized by increasing energy prices and the war in Ukraine) – and how to improve economy and living standards in rural districts in Europe via the development of new agricultural and food systems? In other words, huge challenges and significant disagreements exist in relation to ends and means.

Therefore, and to an increasing extent – the authorities demand research-based policy advice on which to base decisions. Together with questions as to diets and healthy foods, agriculture, food production and the relation of these to climate and environment are among the hot topics on political agendas all over Europe. The major question as to the development of more sustainable food systems receive increasing attention nationally, in the EU as well as global forums.

Research-based policy advice is in high demand, but in more countries both research and policy support are challenged and an object of fierce discussion.

Finding ourselves in a situation with increasing demand as well as increasing pressure on scientific advice, there is a need for a forum in which suppliers of research-based policy support – researchers and advisors – can exchange experiences and find inspiration to develop methods, principles, and practices for the best possible ways to provide qualified, independent, and transparent policy support. If we succeed in developing cooperation relations across countries and institutions, we may achieve an improved utilization of our total qualifications in relation to both policy advice and research.

Aarhus University's faculty of Technical Sciences (AU Tech) has an extensive and long tradition for providing research-based policy support to e.g., the Ministry of Food, Agriculture and Fisheries of Denmark and the Ministry of Environment of Denmark. The policy support is coordinated by DCA – Danish Centre for Food and Agriculture, and DCE – Danish Centre for Environment and Energy. Both centres are the first in Europe to follow a certified ISO 9001 quality management system.



Via the Horizon research programmes, DCA has established strong inter-European research cooperation relations in many of the areas mentioned, and Aarhus University (AU) is a central collaboration partner together with other European universities and research institutions.

Based on this, DCA and DCE organized – in March 2021 – the first trans-European seminar on research-based policy support within agriculture, food, climate, and environment. The seminar was organized in cooperation with the European organization for research-based policy support (ESAF) and supported by the European Commission's Science Advice Mehcanism (SAM) under DG Research & Innovation. More than 200 researchers and advisors from all of Europe participated in the on-line seminar.

The term "research-based policy support" comprises research-based advice as well as the underlying research.

Policy support includes various tasks and assignments, such as accounts, reports, evaluations, monitoring, data collecting and mapping, scientific evaluations etc.

Internationally, the term "science-based policy advice" or shorter terms like science advice are widely used.

In Denmark, policy support is established according to specific agreements between Danish ministries and research institutions.

The seminar demonstrated that in Europe the term "research-based policy support" covers various forms of scientific advice. However, the main purpose is to provide civil service and political decision-makers with updated, verifiable, and evidence-based knowledge to be used in questions as to regulation and political decision-making.

The organization, financing, and responsibility for research-based policy support vary between countries, scientific areas, and sectors. In some countries the organization and financing of the institutions responsible for providing policy support is under pressure.

Regardless of the organization of the scientific policy support, it should be based on principles that ensure quality and reliability. Arm's length to decision-makers as well as transparency in the policy support and the scientific basis are all essential principles for reliability. Other principles concern the scientific stringency, a clear distinction between data and normative assertions, and finally timing of the policy support.

In DCA, we solve about 250 policy support assignments per year. We frequently experience substantial attention in relation to the assignments as well as a huge pressure to deliver tasks within very short deadlines. These tasks are often extensive and complicated and require coordination between several researchers within very different disciplines.

In cooperation with DCE and the Tech faculty, we have thus improved our quality assurance systems. We have introduced improved procedures for examination and peer review to support researchers in maintaining the high quality in policy support. We have certified our quality management system according to the ISO 9001 standard, and we carry out education and training of researchers that provide research-based policy support.

The experiences that we have achieved through these efforts will be available at a European level, e.g. by organizing opportunities for further education of European researchers who work with research-based policy support.

Recommendations from the European seminar on research-based policy support

Independent policy support
As a researcher it is important to focus on the provision of research-based analyses to be used as basis for political processes rather than specific policy advice regarding political decisions. The point is for researchers to be independent and not engage in the actual political decision-making process.

Scientific publication
The research on which policy advice is based, should be published in international scientific journals with so-called peer review, i.e. critical examination by peers.

Integrity and independence
As scientific advice concerns human living conditions, it is essential that the advice provided is objective and independent. This means that the process used to procure the advice is transparent and that it is possible to verify the scientific basis of the advice.

Inter-disciplinary expertise
Many research environments are "mono-disciplinary", whereas the problems they are solving are inter-disciplinary. Therefore, the research environments are responsible for ensuring inter-disciplinarity in policy support.

Knowledge sharing and the public
The universities are under the obligation to put their knowledge at the disposal of society. Research and policy support must be readily available to interested parties as well as the general public, not just the authorities. Researchers should have the opportunity and time to meet with interested parties and present their research.

Research -based policy support

One of a university's core tasks is to provide research and ensure communication of new knowledge. This is accomplished by publication and dissemination of research results, student education and research-based policy support to authorities.

Aarhus University (AU) has entered into an agreement with the Ministry of Environment of Denmark (MIM) and the Ministry of Food, Agriculture and Fisheries of Denmark (MFLF) on the provision of research-based policy support in areas relating to crop production, livestock production and food quality and consumer behavior. The agreement comprises a framework agreement ensuring that AU carries out research to support the administrative tasks in the respective ministries. In addition, the agreement ensures that AU has the necessary knowledge and competence required to provide research-based policy support within the scientific areas comprised by the framework agreement.

About DCA – Danish Centre for Food and Agriculture
Providing policy support in relation to complex questions often requires interdisciplinary collaboration. In order to ensure this within the areas of food and agricultural science, Aarhus University has established DCA – Danish Centre for Food and Agriculture. The centre coordinates cooperation with the Ministry of Food, Agriculture and Fisheries.

Research-based policy support comprises four types of support:

- Research-based advice
- Research-based surveillance and scientific data centres
- Research-based readiness
- Research and general competence building

Read more at **dca.au.dk/en**

DCA comprises AU departments and research environments with activities within the food and agricultural areas, and these are as follows:

- Department of Agroecology
- Department of Animal Science
- Department of Food Science
- Centre for Quantitative Genetics and Genomics
- Department of Engineering
- Department of Biological and Chemical Engineering*

* Department of Biological and Chemical Engineering is in charge of tasks within the engineering field in close cooperation with other AU departments of engineering.

A centre unit supports DCA activities, which – in addition to policy support – further comprise industrial collaboration, international collaboration and communication. In addition, the Centre Unit ensures the involvement of other relevant research environments at AU in order to solve specific tasks in relation to the framework agreement:

- MAPP Centre, Department of Management at AU
- DPU – Danish School of Education

Similarly, AU established DCE – Danish Centre for Environment and Energy to support activities within environment and energy. Within the framework of DCE, the DCA Centre Unit and the DCA departments cooperate with DCE's Departments of Bioscience and Environmental Science as to interdisciplinary policy support, including the cross field between agriculture, climate, nutrient loss, and biodiversity as well as tasks in relation to health hazards of harvesting mussels from Danish waters. Activities within DCE focus areas are not included in this report

What is research-based policy support?
In order to provide qualified advice and support to authorities, the university must possess scientific competence within the area as well as observe the authorities' expectations as to relevance, form and punctuality in the support provided. In order words, research provides the necessary foundation for highly qualified policy support, and the term "research-based policy support" thus comprises both research-based advice and the underlying research.

All public research and policy support should be freely available, and the universities are entitled – and obligated – to publish the results. Researchers' freedom of speech and research are fundamental principles that the universities cherish and protect; also in relation to research-based policy support.

The agreement with the Ministry of Food, Agriculture and Fisheries of Denmark respects the arm's length principle, and DCA's policy support is based solely on the scientific contributions provided by the researchers. The authorities are responsible for the subsequent political and administrative considerations.

Financing food and agricultural research

Different sources fund food and agricultural research, and DCA's contract with the Ministry of Food, Agriculture and Fisheries of Denmark is the main income source. According to the agreement, DCA received 261.3 million DKK in 2020 to cover expenses in relation to the research-based policy support. Of these, 9.5 million DKK were special grants and 7.8 million DKK were acquisitions.

The grant from the Ministry of Food, Agriculture and Fisheries of Denmark allows DCA to attract and carry out research projects in collaboration with organizations and companies. This collaboration, together with grants from national and international funds and research programmes, was the main reason why the total research and development funding within the agricultural and food area amounted to 630.4 million DKK in 2020. This amount includes AU co-funding to the amount of approx. 63.7 million DKK

Participation in partnerships and working groups

According to agreement with the Ministry of Food, Agriculture and Fisheries of Denmark, DCA participates in several international collaborations. These include among others:

- EJP SOIL: European research collaboration on sustainable and climate-smart management of agricultural soils
- European Innovation Partnership on Agricultural Sustainability and Productivity (EIP-AGRI)
- Standing Committee on Agricultural Research (SCAR)
- Collaborative Working Group of Sustainable Animal Production
- Animal Task Force
- NordGen Council for Farm Animal Genetic Resources

DCA participates in – and contributes to – a series of European research programmes; e.g. several European Research Area Networks (ERA-NETs), including SusCrop and ERA-NET SusAn, as well as initiatives within the framework of European Joint Programmes (EJP). In addition, Aarhus University is a core partner in EIT Food

PLANT PRODUC-TION

The Ministry of Food, Agriculture and Fisheries of Denmark (MFLF) and Aarhus University (AU) have entered into an agreement on the provision of research-based policy support within plant production.

The agreement specifies eight scientific focus areas in relation to which AU/DCA carries out research and policy support activities:

1. Plant breeding and pollination, plant health aspects, crop protection and Integrated Pest Management (IPM)
2. Climate-smart production systems
3. Fertilizers, standard values and nitrogen prognosis
4. Technology – agriculture and plant breeding
5. Soils and soil conditions, including digital data, maps and image analysis
6. Green transition and biomasses
7. Targeted area regulation and mitigating measures
8. Agricultural reform and public green goods

Research-based policy support within the area is primarily carried out by researchers from the departments of Agroecology, Food Science and Engineering as well as researchers from Center for Quantitative Genetics and Genomics.

However, researchers from other departments often contribute, especially researchers from the environmental areas comprised by DCE. Interdisciplinary research areas such as e.g. climate and bioeconomy involve cooperation with researchers from various disciplines.

In relation to interdisciplinary research areas such as climate and bioeconomy, researchers from many other areas contribute.

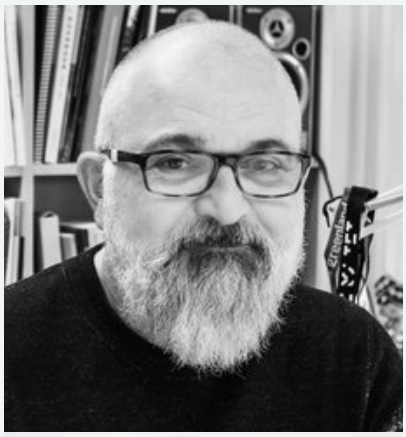
You can read more about our plant production activities in the following.

You can find the entire agreement at dca.au.dk

News in brief

New professors

In the autumn of 2021, three new professors were appointed at the Department of Agroecology. Mogens H. Greve in pedology and digital soil mapping, Inge S. Fomsgaard in natural substance chemistry and environmental chemistry - and Uffe Jørgensen in perennial cropping systems.



Grant to improve important crops

Guillaume Ramstein from Center for Quantitative Genetics and Genomics (QGG) received an Emerging Investigator Grant from the Novo Nordisk Foundation. The grant will be used for research in finding a new strategy to improve fitness of important cereal crops in Denmark, such as wheat and barley.

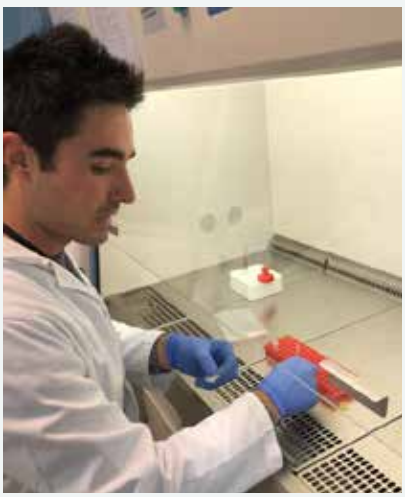
Peat soils made simple

Peat soils, paludiculture, and greenhouse gas emissions were the topics when Claudia Kalla Nielsen won the annual Three Minute Thesis competition at Aarhus University last spring. Participants are asked to explain their research in just three minutes in a way that their grandmother can understand.

Research in soil physics honored with award

Professor Lis Wollesen de Jonge from the Department of Agroecology received the prestigious "Don and Betty Kirkham Soil Physics Award" in the autumn for her great work in research within soil physics. The award is presented by The Soil Science Society of America.

Grant for agricultural drainage water treatment



In the autumn, Arnaud Jéglot from the Department of Agroecology was awarded a Scientific Exchange Grant by the European Molecular Biology Organization (EMBO) to visit the lab of Professor Timothy Vogel in Lyon in France. The purpose is to collaborate to decipher microbial composition of woodchip bioreactors to improve agricultural drainage water treatment under cold weather.

A climate-friendly diet requires less agricultural soil

Providing food for one person following the new climate diet recommendations will require a significantly smaller agricultural area than feeding a person who eats an average Danish diet.

Food production affects the climate as well as the extent of the cultivated areas. Greenhouse gas emissions from food production consist of carbon dioxide from primarily energy consumption, and nitrous oxide caused by the conversion of nitrogen in relation to crop production and manure – and, in addition, methane which comes from animal production but also from e.g. the cultivation of rice.

In the beginning of 2021, the Danish Veterinary and Food Administration introduced new climate-friendly diet recommendations to help us take care of the climate as well as our bodies. However, to which extent will the adoption of a climate-friendly diet affect the size of the total agricultural area – in Denmark and abroad – used to feed the Danes?

Researchers from Aarhus University have investigated this issue at a request from the Danish Agricultural Agency.

- Generally, the climate footprint per kilo food produced is higher for animal products compared to vegetables. This is because emissions per kilo food product increase when e.g. animals eat and metabolize grain contrary to direct human consumption. A more climate-friendly diet will thus consist of a higher share of vegetables and less animal foods, Associate Professor Lisbeth Mogensen, Department of Agroecology and one of the researchers behind the study, explains:

- In addition, a change in the composition of vegetable foods is necessary, a change towards a higher share of products that are rich in protein and energy such as legumes – e.g. beans and nuts. A change is also needed in relation to the animal foods in our diets; we should eat more fish – and generally reduce the amount of meat and dairy products. We have calculated what these changes will mean for agricultural land use

A 39 % reduction in agricultural land use

The new calculations from Aarhus University are based on the report "Råd om bæredygtig sund kost (Guidelines for sustainable and healthy diets)" prepared by the National Food Institute of Denmark, which is the basis for the climate dietary guidelines. The report lists the daily intake of different foods for a person eating a climate-friendly diet compared to a person eating an average Danish diet.

As an example, the average Danish diet contains a daily intake of red meat (pork, beef and lamb) of 137 g, 28 g poultry and 38 g fish, whereas the climate-friendly diet recommends 15 g of red meat, 30 g of poultry and 50 g fish. Accordingly, the intake of milk and cheese is reduced from 319 and 45 g, respectively, in the average Danish diet to 250 g milk and 20 g cheese in the climate-friendly diet.

In order to go from amount of foods to land use, Aarhus University primarily applies a study accomplished by Dutch researchers, who calculate average values for area consumption per kilo food bought for nine food groups, and more of these groups are identical to the food groups used in the tables prepared by the National Food Institute of Denmark.

Based on this, the researchers from Aarhus University are able to demonstrate that climate-friendly diets will significantly reduce the need for agricultural farmlands:

- Based on the tables from the National Food Institute of Denmark illustrating the two dietary patterns – the average Danish diet pattern and climate-friendly diet, respectively – our calculations demonstrate a land use consumption per person per day of 5.12 m2 for the current dietary pattern. This figure can be reduced by 39 % to 3.13 m2 per person per day for the climate-friendly diet. This reduction in land use consumption will be partly in Denmark and partly in the countries from which we import feeds and food, Lisbeth Mogensen explains, and she further adds:

- In the average Danish diet, 56 % of the land use area is used to produce red meat and poultry, and animal foods account for 78 % of the total land use, when we include the production of dairy products, eggs and fish feed. Application of the climate-friendly diet will only require 22 % of the area to produce red meat and poultry, and the total production of animal foods will require 44 %, when land used for diary production, eggs and fish feed is included.

Read more at
dca.au.dk/en

Why do different wheat cultivars respond differently to climate change?

Global climate change is putting pressure on our wheat crops with rising temperatures, droughts and higher concentrations of CO_2, but the different wheat cultivars respond very differently.

Rising temperatures, drought and higher concentrations of CO_2. Global climate change is putting pressure on all food crops but the responses might vary.

Wheat cultivars respond differently to various types of climate stress. Researchers from Aarhus University, among others, have taken a closer look at the reason for this. Research efforts took place within the framework of MODCARBOSTRESS, a European research network with partners from seven universities.

Based on the two wheat cultivars Paragon and Gladius, researchers have shed new light on what separates their reactions from each other when exposed to different forms of stress at the same time, and they can now conclude that the two wheat cultivars differ significantly in their growth and physiological response to climate change scenarios:

- The photosynthesis of Paragon was particularly negatively affected by heat stress, and to some extent by water stress, while Gladius was particularly affected by water stress. Yet Gladius developed faster than Paragon under water stress. Gladius was able to produce the same amount of biomass as during ordinary irrigation, especially by developing the biomass in the stem and plant height and by producing the flowering shoots early, however at the expense of the leaf mass and the production of shoots, says Carl-Otto Ottosen and adds:

- Overall, Gladius proved to be more resistant to several simultaneous stressors. Gladius thus has greater phenotypic plasticity - it is simply better at adapting to changing environments. It is new knowledge and another piece in our work to climate-proof the wheat of the future.

More grassland to improve climate and environment

Grassland areas may reduce agricultural emissions of greenhouse gases and nutrients. Together with newly developed biorefining technologies, grasslands constitute a breeding ground for new sustainable products.

When you grow perennial grass fields, carbon stocks are stored in the soil, and the CO2 stored in the soil will not impact the atmosphere. Cultivation of grass does not require pesticides, and compared to annual crops the nitrate leaching from perennial grass fields is much lower.

- Increased cultivation of grass and clover will thus contribute to fulfilling both climate goals and the EU Water Framework Directive, says Professor Uffe Jørgensen, Aarhus University Centre for Circular Bioeconomy (CBIO).

At the same time, Uffe Jørgensen points out that research and development of new biorefining technologies will allow the use of grass for various purposes. For instance, it is possible to extract protein and other high-value products from grass, while residual products can be used for e.g. feed and renewable energy.

- This will allow us to produce sustainable protein instead of importing it from other parts of the world. However, several factors prevent us from harvesting all the benefits at the moment, says Uffe Jørgensen.

We lack e.g. tools to document the long-term effects of grass cultivation. Authorities as well as food companies point out that solid research documentation is necessary if we are to calculate the effect of grass and clover on soil carbon contents.

New research project to improve official credit systems

As no official credit systems exist yet, today's farmers are not credited for growing climate-friendly crops. Among other reasons, this is due to the fact that it is difficult to determine the effect as it depends on the type of grassland, fertilization, duration of crop cultivation and the way in which the grassland is converted to subsequent crop cultivation.

A new research project "GrassTools" will try to improve this. Within the framework of the project, new tools will be developed that will make it possible to document and utilize the grassland potential.

One of the new tools to be developed in the GrassTools project, is a simple and very precise method (based on the so-called qPCR technology) to measure the amount of roots in different varieties of grass and clover. This new tool will help to identify the roots of any given variety, and thus also its potential for CO2 storage.

This information – together with information on e.g. crops, soil type, fertilizer etc. – will be analyzed by means of mathematical models that are also developed in the project. The models will determine the total effect of grass cultivation on the aquatic environment and climate, and thus form the basis for the certification of the impact.

Another tool to be developed within the framework of the project, are applications for Yara's N-sensor in grassland. Correct fertilization of a grass field depends on e.g. soil type and the species composition of the crop. The N-sensor calibration will be developed in order to consider these factors.

Partners from the agricultural sector, the industry, authorities and the research participate in GrassTools. A major goal will be the discussion of how to quantify and document the positive effects of grasslands in order for these to be part of a future optimization of the climate and environmental efforts of agriculture.

Methods for a well-documented quantification of organic carbon are essential for the possible handling of climate credits.

CO_2 conversion using a new Power-to-X system

Using excess electricity from wind and solar power, and CO2 from biogas, a new research and development project is aiming to produce biomethane in a pilot-scale experiment. The experiment is an important step in the Power-to-X technology.

A new pilot-scale project called InjectMe is bringing together expertise from the company Landia in western Jutland, the University of Queensland in Australia and Aarhus University to develop a cost-effective system for biogas-methanation.

The project will develop a biological methanation system to convert electricity and biogas into natural-gas-quality biomethane (Power-to-Methane). By producing methane from renewable electricity and CO2, which would otherwise be emitted into the atmosphere, the concept contains elements of both energy storage and carbon capture.

- In fact, we're just stimulating a process that already occurs in a biogas reactor by making sure that there's enough hydrogen for the microorganisms to convert as much CO2 as possible. By doing this, we're recycling a large part of the CO2 from the biogas process that would otherwise be released into the atmosphere, says Michael Vedel Wegener Kofoed, a researcher at the Department of Biological and Chemical Engineering at Aarhus University and the project manager on InjectMe.

The project has a budget of DKK 12.1 million and it is being funded by the Energy Technology Development and Demonstration Programme (EUDP) under the Danish Energy Agency.

The green transition can also be blue

Blue biomass is the term for resources from the sea, which we can exploit much more sustainably both on the dinner table and as tool for environmental restoration.

The world's population is expected to reach 9.8 billion people by 2050. Both globally and nationally, there is a strong focus on the need to restructure food production to increase public health and reduce the negative impact on the environment and climate.

In both contexts, increased production of food from the sea can be part of the solution. This is the conclusion of a report by DTU Aqua and Aarhus University, prepared at the request of the Ministry of Food, Agriculture and Fisheries of Denmark. The report emphasizes that blue bioeconomy can support the green transition.

The report, which is in Danish and entitled "Vidensyntese om blå biomasse" (in English: "Knowledge synthesis on blue biomass"), deals with society's ability to meet the future demands for a more climate-friendly and sustainable food production through transition to food from the sea.

Read more at **dca.au.dk/en**

Why not combine agriculture and solar energy on the same field?

Using vertical solar-cell installations, researchers from Aarhus University will harvest both energy and crops from the same agricultural area.

Hunsballe Grønt fruit farm is situated in Skælskør on the Danish island of Zealand, and here Claus Hunsballe has a total of 250 hectares of farmland under cultivation, with all sorts of fruit and vegetables. Claus Hunsballe and his family have been doing this for the past 60 years, and he plans to continue to do so.

But he also wants to produce some of the electricity that his farm consumes in pumps, ventilation systems, and so on.
- We've got windbreaks around the farm, and I thought it would be a good idea to get more out of them. They're just standing there, but the optimal for me would be if we could use the surfaces both to shelter the plants and to produce electricity, says Claus Hunsballe.

For this reason, he has joined a major EU project designed to make it possible to grow crops and, at the same time, harvest solar energy from the same field.

The project is called Hyperfarm, and it is being funded by a total of DKK 41.3 million from the EU Framework Programme for research and innovation, Horizon 2020. In addition to Hunsballe Grønt, the development company AgroIntelli and Aarhus University are also taking part from the Danish side.

Energy when it is needed

The focal point of the project is so-called bifacial solar cells; installations that can convert the sun's rays into energy from both the front and the back. Associate Professor Marta Victoria from the Department of Mechanical and Production Engineering at Aarhus University is in charge of the university's engineering work in the project and she explains:

- Unlike conventional photovoltaic units, these solar cells can be placed with the faces permanently facing east-west. Because of their bifacial properties, they harvest energy from the sun in the morning, as well as in the afternoon and from the late evening sun in the summer. So, we aren't necessarily aiming to get the most energy out of the solar cells, but rather we're looking to harvest the energy at the times when there is the greatest need, she says.

In brief, the project will explore the possibility of building rows of 2-4-metre-high vertical "solar cell walls" in fields with different crops. The crops could be anything from grain and beans to vegetables and fruit like Claus Hunsballe's strawberries and blueberries.

On ordinary grain fields, the rows will be placed 10 metres apart, so that agricultural machines can operate between them. This will optimise the relationship between agricultural and energy production, as the rows will not shade each other.

Windbreaks are important for crops

In addition to energy production, the solar panels will serve as windbreaks for the crops in the field. They will provide shelter from the wind, prevent soil drifting and reduce the water consumption of the crops.

- We know from previous studies that shelter gives approx. 10 per cent higher yields from a field. The project will examine these conditions in more detail and it will test whether there are any further potentials for the crops, for example minimising fungal attacks and the need for pesticides, says Professor Uffe Jørgensen from the Department of Agroecology at Aarhus University.

In the project, Hunsballe Grønt will install a new solar cell windbreak, and a demonstration installation will also be built at Aarhus University's research centre in Foulum, where the method will be tested with different crops. In addition, AU will study what citizens and consumers think about different types of solar-cell installation. This particular research will be conducted from the MAPP Centre at Aarhus University.

Hyperfarm brings together eleven partners from four different European agricultural countries (Belgium, Germany, the Netherlands and Denmark). The project started at the end of 2020.

Image recognition optimizes supply of nitrogen

Machine learning maps the distribution of grass, clover and weeds on the farmer's clover grasslands, so that he more easily can adapt his supply of nitrogen.

Clover and grass do not have the same need for nitrogen in fertilizer. Where grass has a great need, clover has no need, making it difficult to optimize the supply of nitrogen on clover grasslands. An optimal supply depends on the proportion of clover in the field, but the growth conditions vary from place to place, year to year and season to season. There can even be large local differences within the same field. In other words, the need for fertilizer can be very different even in within small areas.

Therefore, there has been a focus on developing camera solutions that can read the amount of clover and grass in the field for many years.

Knowing the difference between clover and grass

- There have been many efforts to develop such camera solutions, but it has been difficult to put into practice, but we have now found a model and method that seems to work, says professor and section leader Jørgen Eriksen from the Department of Agroecology at Aarhus University.

Here, researchers have used a DeepLabv3+ model, which is trained to know the difference between grass, different clover species, weeds and soil in pictures taken under different weather conditions.

- Our model is able to predict the actual proportion of clover, which in the experiments was determined by a simple botanical analysis. That is, the plant species had been sorted and weighed. And it did it with a degree of explanation of 91%, and for mixtures with grass and white clover the degree of explanation was even 95%, says Søren Kelstrup Skovsen from the Department of Electrical and Computer Technology at Aarhus University.

Breakthrough for the nitrogen supply

It is not the model alone that has ensured the breakthrough in image recognition of clover and grass species on the farmer's field. Some are also attributed to high and consistent image quality, just as an efficient image collection plays a big role. If the DeepLabv3 + model is to be used for mapping fields, it must use up to 200 images per hectare.

During the experiment, a camera mounted on an ATV collected high-quality images even at speeds of up to 50 km/h. That corresponds to 17 hectares per hour.

- It is really a breakthrough in relation to the farmer's ability to optimize the fertilizer supply in the individual clover field based on the proportion of grass and clover. Our goal is an optimized nitrogen supply for the benefit of both feed quality, economy and the environment, says Jørgen Eriksen.

Harvest date model also benefits cover crops

A new model uses air temperature to estimate the date of harvest of certain crops. It also benefits the growth and ability of cover crops to reduce nitrogen leaching.

According to Danish regulations, cover crops must be sown no later than 20 August. This means that the main crop must be harvested before that date.

- But many farmers in the northern part of Denmark have a hard time with this, as the grain is not ripe for harvest yet. If the weather has been unfavorable, you can get a dispensation, says post doc Johannes W. M. Pullens.

He has been involved in developing a model for predicting harvest dates, e.g. in order to ensure an earlier effort in relation to being able to postpone the deadline for the establishment of cover crops.

- Our results show great potential to shorten the period from maturity to harvest. And if the harvest is closer to the ripening date, you will also be able to sow the cover crops a little earlier. This improves the growth of the cover crops, and it will provide a larger biomass and thus reduce the leaching of nitrogen. But it requires that in some cases farmers have to harvest grain with a slightly higher water content than desired, explains Johannes W. M. Pullens.

Read the entire news article here

These plants have great potential for loosening compacted soil

Lucerne and chicory show great potential for loosening heavily compacted soil over prolonged cultivation.

Heavy machines in the fields compact the soil. When the soil is compacted, the number and sizes of the pores are reduced hindering the transport of oxygen and water. It inhibits agricultural production and affects the environment when the subsoil is compacted and natural recovery takes a long time.

One method that can help rebuild the pore structure and improve the soil again is to use plants and their roots. However, it is not without problems either, as many plant species have difficulty growing in compacted soil.

- In these experiments, we have chosen five crops that can grow in compacted soil, says Professor Lars Juhl Munkholm, who has used a medical CT scanner to measure the crops' ability to loosen packed soil.

- Our experiments show that chicory and alfalfa contribute to the development of a large number of complex pores, and this indicates that the two crops do better than the other three. They create a larger, more connected and complex pore network, explains Lars Juhl Munkholm.

The five plant species in the experiment:

1. Lucerne
2. Chicory
3. Fodder radish
4. Kernza
5. Tall fescue

Read the entire news article here

Map of water movement in the soil's macropores

New map of water transport in the soil's macropores can be used to identify risk areas for phosphorus or pesticide leaching.

In the soil under our feet there are pores of different sizes. The largest are called macropores, and they can create direct transport routes between the soil's root zone and field drains or the upper groundwater. They not only create a pathway for water, but also a create risk in relation to the leaching of phosphorus and pesticides.

Therefore, water transport in macropores has been studied and mapped for the whole of Denmark in order to be able to identify risk areas for leaching.

- We have made a risk map of macropore transport in Denmark, which shows the risk of the different soil types for macro transport during different amounts of precipitation. And if you link it with the soil's risk of colloid transport, then it will be possible to assess the risk of leaching of e.g., phosphorus through the macropore system, says associate professor Bo Vangsø Iversen from the Department of Agroecology.

New method provides insight into the soil's many functions

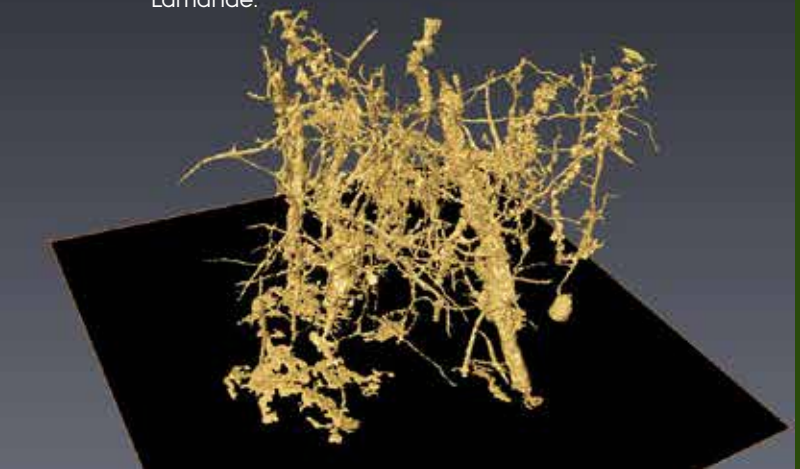
CT scans and 3D printing have created a better understanding of the soil's complex pore systems for gas and water transport.

The soil has a complex pore system. It affects the growth of the plant and how nutrients are absorbed. In an attempt to optimize plant production and minimize negative effects on the surrounding environment, researchers from the Department of Agroecology have used a combination of digital imaging, physical models and laboratory measurements to describe the pores in the soil and their effect on various soil functions, in this case transport of gases.

- It is not yet possible to make a complete reconstruction of the soil's structure or architecture, but it is possible to construct a soil model and use 3D printing to make a partial reconstruction. By combining CT X-ray images with measurements of air transport in the pores, we can actually get a good image of the complicated geometry with a resolution of a few micrometers, says senior researcher Mathieu Lamandé.

The experiments at Aarhus University confirm that the combination of CT scans and 3D printing is suitable as a conceptual model to describe the impact of soil structure on gas transport. However, according to the researchers it is important to take into account the resolution of the CT images and the 3D printer in relation to the type of pore structure one is trying to reconstruct.

- The method is not perfect, there are elements that must be taken into account. If you do that, then our study shows that there is a great potential for using 3D-printed soil samples to reconstruct the soils's macropore network for a better understanding of its functions, says Mathieu Lamandé.



Plants deposit carbon as they grow

Measurements and data from Foulum show that up to 10 percent of the total supply of carbon from cover crops to the soil comes from growing plants.

There is a strong focus on reducing the climate footprint of agriculture, and one way to do this is to sequester more carbon in the soil by optimizing the cultivation of crops and cover crops. As long as the carbon is stored in the soil, it is not converted to CO_2 and emitted into the atmosphere.

- Although cover crops are very widespread in Denmark, we do not know much about what they mean in relation to carbon in the soil. In order to optimize the carbon supply from cover crop mixtures, we have examined the plants' input of carbon - not only in the form of biomass, but also the depositing that take place while the plants are growing, says PhD student Esben Øster Mortensen from the Department of Agroecology.

Using an improved method, it has been possible to quantify not only the carbon added to the soil from the biomass that is decomposed, but also that from the carbon deposition of the plants.

- Plants deposit a quantity of carbon as they grow, and this pool of carbon is probably more stable in the soil than carbon from the biomass itself. In this experiment, we have investigated and quantified the carbon that comes from the plants' deposit, just as we have investigated how different cultivation systems affect this particular type of carbon supply, says Esben Øster Mortensen.

The experiment showed that the plants' carbon deposition for between 3-10 percent of the total supply of carbon from the plants. It also turned out that this pool of carbon depends on how much nitrogen is available in the soil in advance. At a higher nitrogen availability, less carbon was deposited during growth, even though the total biomass was higher.

Resistance warning

Resistance has been found in annual meadow grass (poa annua) in widely differing crop rotations, prompting researchers to sound the alarm.

A single annual meadow grass plant can produce up to 500 seeds, it can spread quickly and is one of the most common weed species in Denmark. Now studies have shown that it is developing resistance to herbicides, and researchers therefore assess that the plant has the potential to become a so-called super-spreader.

- It is a worrying development that we have witnessed, and we must do our best to delay the development of resistance. This can be done, for example by having a varied crop rotation, where you can reduce the problems through tillage, sowing time and mechanical control and thus reduce the need for herbicides. It is important that we act now, says senior researcher Solvejg K. Mathiassen from the Department of Agroecology at Aarhus University.

Did you know that...

Plants can scare away harmful root parasites such as nematodes away themselves?

- In the fight for survival, plants have developed defense mechanisms to prevent them from being attacked by plant parasitic nematodes. They simply produce defense substances against their enemies, says senior researcher Mette Vestergård Madsen from the Department of Agroecology at Aarhus University.

Drones for controlling grass lodging

A new method uses drones to identify the areas in the seed grass field that are often affected by grass lodging.

Grass seeds are grown for DKK 23 billion € per year in the EU, and a large part of that production takes place in Denmark. The value of Danish exports of field seeds, garden seeds and industrial seeds is stated by Landbrug & Fødevarer at DKK 3.4 billion in 2019. Unfortunately, many seed growers experience problems with early and heavy grass lodging, especially if they do not have control over growth regulation and nitrogen supply.

There are various strategies to avoid grass lodging. Growth regulation is one of them, but it requires great knowledge and precision to get the most out of one's growth regulation.
- You can also stop fertilizing so much, because over fertilizing often creates problems with grass lodging. But if you fertilize less, the yield will also be smaller, so it may not be an optimal solution either, says associate professor René Gislum from the Department of Agroecology.

Grass lodging often appears in the same place in the field year after year, and with the help of drones one can find out exactly where these areas are.

- As soon as we have a picture of where in the fields the crop is affected by early grass lodging year after year, we can implement different mitigation strategies. Our drone trials have the potential to generate maps of grass lodging, thereby and thereby help increase grass yield at farm level, says René Gislum.

Kill the common wild oat

Common wild oat (Avena fatua) can cost agriculture dearly, now researchers are giving with good advice on how to best deal with and dispose of the stubborn weeds.

It is mandatory to fight common wild oat, and the "flyvehavrelov" helps to prevent common wild oat from becoming too widespread and thus costing agriculture a lot of money.

According to researchers from the Department of Agroecology, proper handling of plant material and areas can prevent the spreading of common wild oat from infected areas:

- biogas - ripe common wild oat seeds lose their germination capacity during the process in biogas plants
- heat treatment in connection with biogas - it is estimated that 70° C for one hour will destroy the germination capacity of most of the common wild oat seeds that were not neutralized in biogas production
- ensilage - ensilage of both grass and whole seed for 8-13 weeks can effectively destroy the germination capacity of common wild oat seeds, provided an ensilage process with an effective acidification that lowers the pH approx. 4.
- Do not till the soil for a period after seed throwing on infected areas - common wild oat have germination rest, and resting seeds left untouched on the soil surface are quickly metabolized by e.g. fungal infestation.

New weed have seen the light of day in Denmark

Rattail fescue has become a bigger and bigger problem in winter crops and seed grass in recent years. Researchers share the latest knowledge about the species and how to control it.

Rising prevalence of rattail fescue in Europe and Denmark is causing concern. The weed species is well known in the United States and Australia, where it has caused major problems.

- In seed grass, rattail fescue is particularly problematic, not only because it lowers yields, also because it can be very difficult to sort from the main crop. In winter crops, it is more a question of it causing large yield losses if it is allowed to spread, says professor and section leader Per Kudsk from the Department of Agroecology.

It is not without reason rattail fescue has created major problems. From a purely biological point of view, it has a property which is problematic from an agricultural point of view, as it is very insensitive to most of the herbicides used to control grass weeds. Rattail fescue can be controlled

Although rattail fescue is a very competitive weed species that in experiments at AU Flakkebjerg showed to be able to cause up to 40 percent yield loss in winter wheat, there are still control strategies that can be used.

- There is no doubt that if you choose to plow, you would have far fewer problems with rattail fescue. But there are a lot of farms that practice reduced tillage, and therefore we have a lot of focus on how and whether you can control this weed species also in plow-free systems, says Per Kudsk.

Here, integrated strategies play a major role, because a combination of cultural-technical initiatives such as more spring crops, late sowing of winter seeds and competitive varieties with chemical control are, according to the researchers, the way forward in agriculture with or without plow-free systems.

ANIMAIL PRODUC-TION

The Ministry of Food, Agriculture and Fisheries of Denmark and Aarhus University (AU) have entered into an agreement on the provision of research-based policy support within animal production.

The agreement specifies six scientific focus areas in relation to which AU/DCA carries out research and policy support activities:

1. Breeding and genetics of livestock breeds
2. Animal behaviour and welfare
3. Feed and nutrition
4. Nutrient cycle management and livestock manure
5. Production systems, management and advisory service
6. Animal production and mitigating measures

You can find the agreement at dca.au.dk

Research-based policy support within the area is primarily carried out by researchers from the departments of Animal Science, Molecular Biology and Genetics, and Engineering. However, researchers from other departments often contribute.

You can read more about our animal production activities in the following.

News in brief

New head of department

Professor Charlotte Lauridsen replaced Klaus Lønne Ingvartsen as head of department at the Department of Animal Science in the fall of 2021. The new head of department sees future animal research as a key area that, through collaboration and innovative interdisciplinarity, may contribute crucial knowledge and expertise to a number of challenges related to the green transition.

New professors

In the spring, the Department of Animal Science appointed Peter K. Theil and Margit Bak Jensen as professors, and in the autumn, Peter T. Thomsen followed suit.

With the appointment of Peter K. Theil, the institute strengthens its research into pig nutrition, lactation physiology and productivity - and with the appointment of Margit Bak Jensen and Peter T. Thomsen its strong position in animal welfare and management of welfare-related production diseases in livestock herds.

Greta Thunberg and the BBC came to visit

In the Summer of 2020, Greta Thunberg visited Aarhus University in Foulum together with a BBC camera crew in connection with the TV show "A Year to Save the Planet", airing on Danish TV channel DR in January 2021. She talked to Mette Olaf Nielsen from the Danish Cattle Research Centre, who carries out research in reducing methane emissions from cattle by means of adding additives to their feed. So far, it seems realistic that we can reduce emissions by as much as 30-40 %.

This visit was not BBC's only visit to Department of Animal Science. Earlier this year, Mette Olaf Nielsen presented recent research in climate-friendly cattle in the episode "Farmers on the frontline" in the BBC series "Follow the Food".

Sustainable breeding programmes that are socially acceptable

Researchers from Aarhus University participate in a new EU Horizon2020 project which aims at developing more sustainable breeding programmes in line with social demand.

Genetic selection has brought substantial progress to farmers since the early 1970s. Selecting the best individuals has increased productivity and ensured animal fertility and health as well as reducing the use of resources and environmental impact. Especially in the last decade, Genomic Selection (GS) has sped up and has provided opportunities to extend the number of selected traits.

The main goal of the RUMIGEN project is to produce robust and efficient cattle able to manage the trade-offs between production and adaptation to extreme climate conditions (heat stress, reduced feed qualities and quantities, and disease pressures).

The researchers from Aarhus University will contribute to the project via a study of the interaction between the genotype (the cow) and its environment by means of data from two extreme climate conditions: a temperate climate (Denmark), and a tropical climate (India). The researchers will develop new models that allow for an analysis of inter-disciplinary data for environmental efficiency in order to identify the "most suitable" cows for a specific environment. This means that when a Danish breeding company sells genetic material to a temperate climate (Africa), they will select other animals than for e.g., North America.

In livestock breeding the natural, genetic variation between individual animals is applied in order to achieve permanent and cumulative improvements. However, recently genome editing has been suggested as a promising technology to speed up the selection of animals.

This raises both technical and ethical issues. In order to address the societal issues and improve the public's understanding of new animal breeding technologies, the RUMIGEN project operates with the term 'room of acceptance'.

Such a "Room of acceptance" will be used to develop scenarios that outline the particularities of new techniques and their implications for society, citizens, environment, and animals: What is the 'societal readiness level' in terms of acceptance of new technologies among European citizens? In which ways and in which areas of production would society be ready to accept new technologies?

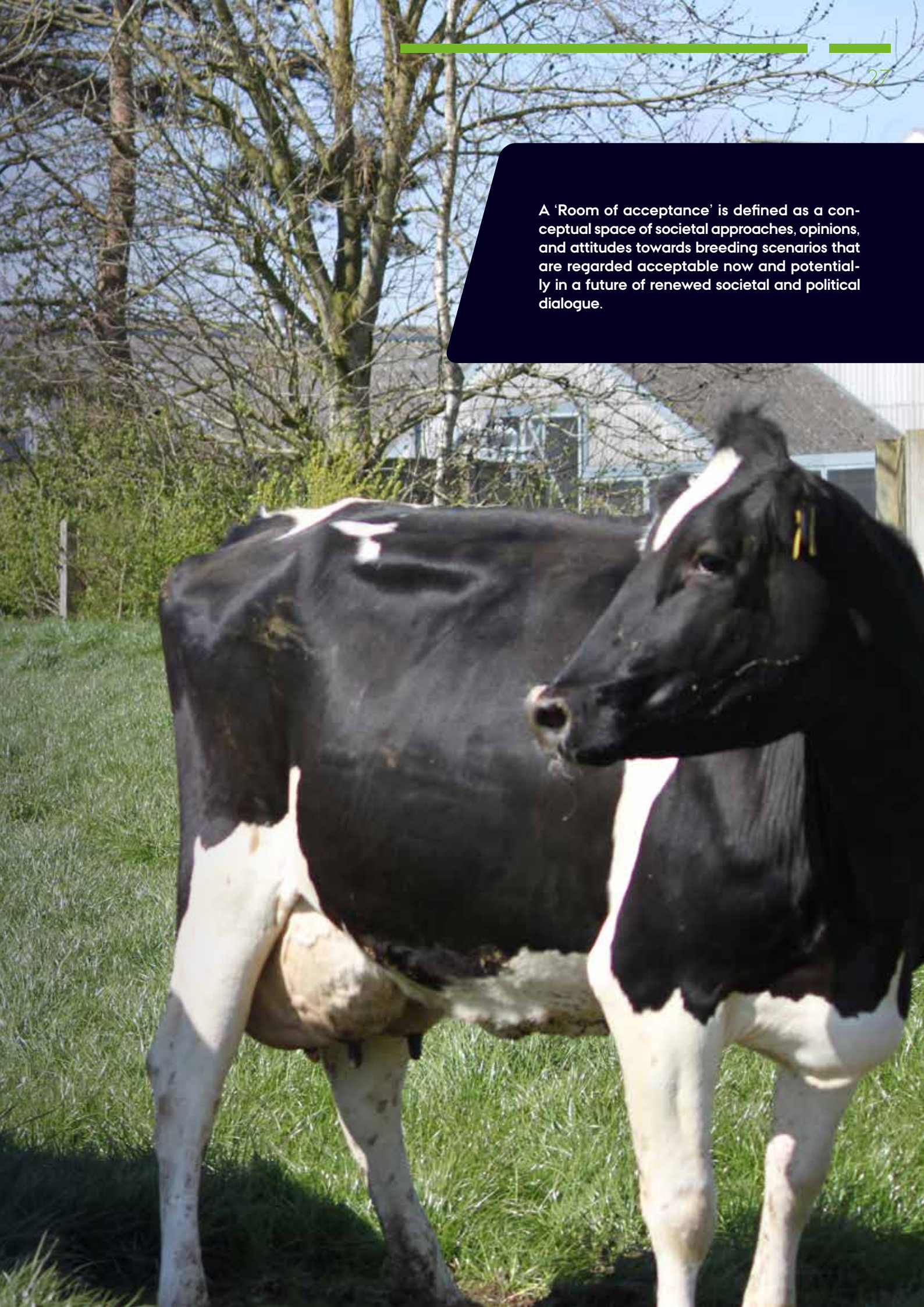
- "RUMIGEN is a large-scale study on the impact of epigenome on phenotype especially under environmental stress", says Senior Researcher, and Work Package responsible, Goutam Sahana from Aarhus University says, and he further adds:

- The researchers from Aarhus University will participate in both identifying the genomic regions under epigenetic control and validating their effects with real data from extreme environmental conditions. This will be generating new knowledge and simultaneously applying to practical breeding.

- Another unique aspect of RUMIGEN is accessing societal acceptance of future breeding technologies. This has become of paramount importance with growing public awareness, not only on how the food is produced but also the technologies' future impact on public health and climate change, Goutam Sahana explains.

Read the entire news article here

A 'Room of acceptance' is defined as a conceptual space of societal approaches, opinions, and attitudes towards breeding scenarios that are regarded acceptable now and potentially in a future of renewed societal and political dialogue.



Project to make livestock farming more sustainable

Danish expertise is at the forefront of a new pan-European research project to develop sustainable systems for livestock farming in collaboration with local livestock farms.

Globally, agriculture emits about one-third of all greenhouse gases, and livestock farming alone is responsible for approx. 70 per cent of the greenhouse gases emitted by agriculture in Europe.
A new research project comprising 28 partners from all over Europe therefore aims at making livestock farming more sustainable. The project is called Pathways, and it has received EUR 9 million or approx. DKK 67 million from the EU Framework Programme for Research and Innovation, Horizon 2020.

- "Within the framework of the project, farmers, researchers, and other experts will work together and develop methods and guidelines as to how we best help develop European livestock farming to make it significantly more sustainable in the future. It is important for the success of the project that local farmers take ownership of the new methods, so that we can develop common scenarios as to how livestock farms can realistically develop in a positive direction," says Professor Claus Grøn Sørensen from the Department of Electrical and Computer Engineering, who is responsible for Aarhus University's contribution to the project.

The collaboration between project partners, local farmers and other stakeholders will take place in 16 practice hubs, locally anchored throughout Europe. In the various hubs, efforts will be made to solve the specific challenges and issues that farms may face today in their efforts to increase sustainability.

The solutions will be compiled in the form of guidelines and standards that may help other farms to start a sustainable transition. The standards will include specific proposals for sustainability initiatives focusing on climate, animal husbandry, technology, profitability, consumer mentality, etc.

Read the entire news article here

Award for research in methane emissions from cows

Professor Mette Olaf Nielsen, Department of Animal Science, received the Danish Dairy Board's Initiative Award for her research in the reduction of methane emissions from cows.

- It is very encouraging when researchers and other experts, quite literally, study the cow's rumen and find a method to significantly reduce the methane production taking place as the cow digests its feed. We truly appreciate this. And therefore, we present this year's "Dairy Award" to Professor Mette Olaf Nielsen, who – together with colleagues from the University of Copenhagen and Aarhus University – has identified a method to impact the process that develops methane.

With these words, Jørgen Hald Christensen, Director of the Danish Dairy Board, explained why the Initiative Award – also known as the Dairy Award – in 2021 was awarded to Professor Mette Olaf Nielsen, Department of Animal Science at Aarhus University. The award was presented at a meeting in the Danish Dairy Board on Friday 21 May.

Together with her colleagues, Mette Olaf Nielsen discovered that if certain bioactive substances were added to the cows' feed, these were able to suppress the special microorganisms that produce methane when feed is metabolized in the cow's rumen.

Following a series of experiments with living cows, the researchers demonstrated that a substance, so far known as X, was able to reduce methane production with as much as 30-40 %. Certain Nordic macro algae also produce bioactive substances that inhibit methane production. The aim is to develop feed additives to be used in Danish cattle farms within a few years' time.

Official opening and open house event at the cattle research facilities at AU Foulum

Around 500 interested visitors dropped in at the cattle research facilities at Aarhus University in Foulum during the official opening and open house event.

Wonderful sunshine and calm weather set the perfect scene for a demonstration of the new cattle research facilities at AU Foulum. AU Foulum started using the facilities back in February 2020, but due to the corona pandemic the official opening and open house event were postponed until 2021.

Official opening

Tuesday 31 August 2021 was the day for the official opening of the new cattle research facilities. Rector Brian Bech Nielsen; the dean for Technical Sciences, Eskild Holm Nielsen; the management team from Department of Animal Science and several other specially invited guests participated at the opening of the facilities.

The opening offered speeches and a guided tour of the centre's new settings consisting of four new barn facilities. At the same occasion, the recently resigned head of department, Klaus Lønne Ingvartsen, was thanked for 14 years of energetic effort and contributions to position Aarhus University as a leading university within international agricultural research. Furthermore, Charlotte Lauridsen was welcomed as the new head of department at Department of Animal Science, Aarhus University. Charlotte's first day of work as head of department was 1 September 2021.

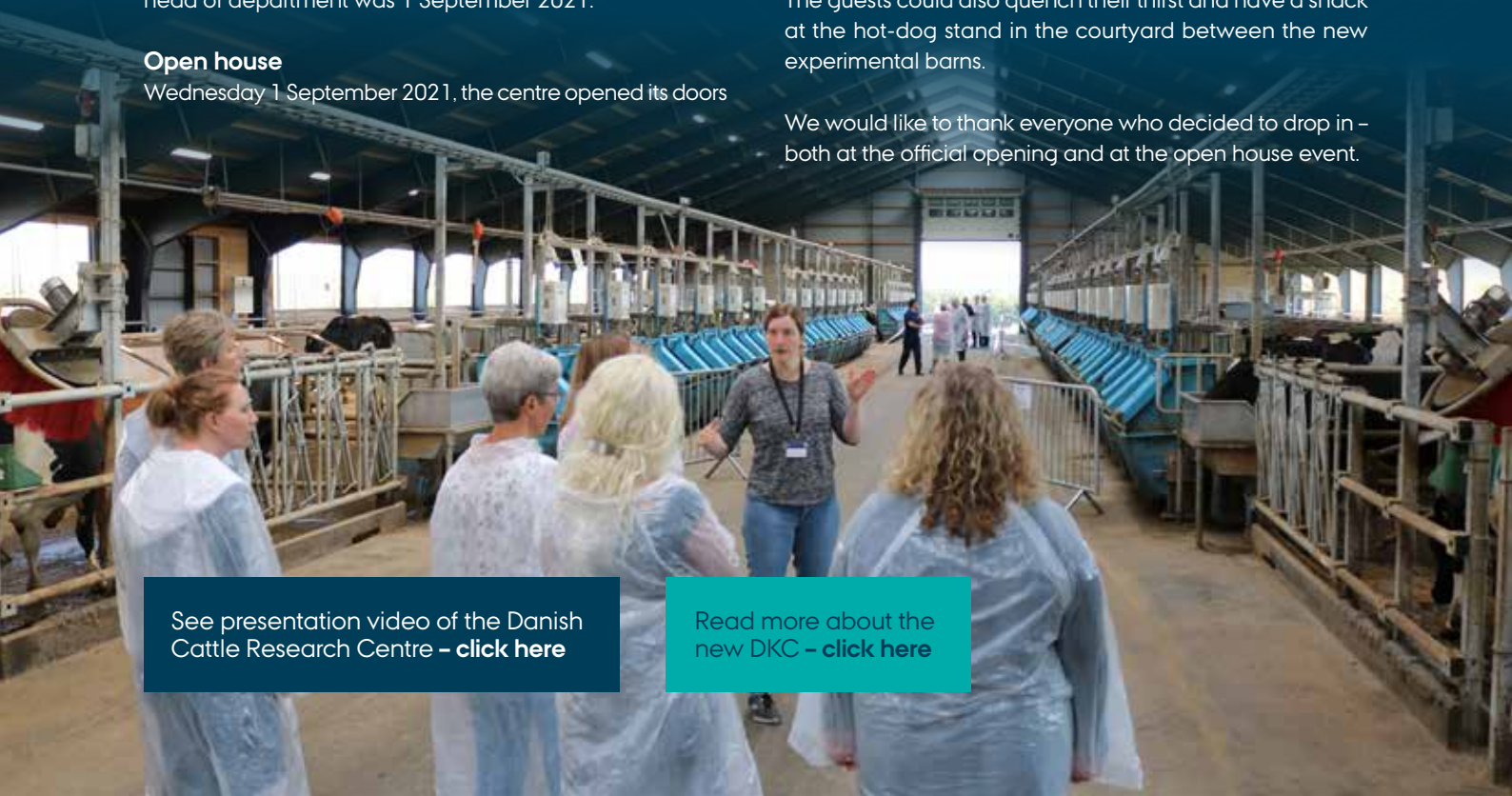
Open house

Wednesday 1 September 2021, the centre opened its doors again – this time for an open house event for everybody interested, and many took the opportunity. Approximately 450 guests decided to drop in to inspect the impressive research settings for cattle.

Head of centre Jens Bech Andersen gave a welcome speech, and the centre employees and cattle researchers at Aarhus University were ready in the various barn sections to tell about the many possibilities for current and future research activities, enabled by the unique research facilities. Among other things, the new research facilities comprise a new cattle barn with electronic feeding troughs and equipment for measuring the methane emission, a new milking parlour including a technique basement, a flexible barn for behavioural studies and not least a new intensive barn with four climate chambers and 20 single boxes customised for loose-housed gut- and rumen-fistulated cows. In this part of the intensive barn, guided tours were planned at fixed hours during which the guests were given the opportunity to see the cows with "a hole in the stomach".

Furthermore, HMC and SAC, who led the turnkey contract, and a number of subcontractors were present at their stands. The guests could also quench their thirst and have a snack at the hot-dog stand in the courtyard between the new experimental barns.

We would like to thank everyone who decided to drop in – both at the official opening and at the open house event.



See presentation video of the Danish Cattle Research Centre **– click here**

Read more about the new DKC **– click here**

New knowledge on anaesthesia when disbudding calves

Despite preceding local anaesthesia, more than 40 % of calves show behavioural responses at disbudding – especially when using a hot iron with a big tip.

In modern dairy cattle production, it is common practice to disbud calves in order to limit the risk of the animals hurting each other or humans. In Denmark, you are only allowed to disbud calves younger than three months. The only legal method is to use a hot iron after a veterinarian has applied local anaesthesia prior to the procedure. In Denmark, the only drug legal for local anaesthesia when disbudding is procaine.

The efficacy of procaine when it comes to disbudding of calves has been studied in a master's project at Aarhus University. The experiment was conducted in eight Danish dairy herds, and the calves' reactions to the disbudding were observed focusing on three types of behavioural responses:

1. The calf gets up on all four legs
2. The calve kicks with at least one leg
3. The calve lifts its head.

Two types of hot irons were used in the experiment: one of 23 mm and one of 33 mm in diameter.

The results showed that 42 % of the calves reacted with at least one of the behavioural responses during disbudding. So, the results suggest that some calves were not sufficiently pain relieved during the procedure. Furthermore, it also seems that the size of the hot iron is of importance as more calves showed behavioural responses when using the big hot iron compared to using the small hot iron.

Cattle can learn to eat weeds in the field

From nature's side, cattle are rigid when it comes to feed preferences; however, they can learn to crop weeds directly in the field thus helping control and at best even fight for example docks.

A pilot study conducted at Aarhus University through a master's project showed that in some cases cattle learned to eat docks directly in the field. This was achieved by means of a relatively simple method of adaptation running for seven days.

The method was tested in 10 beef cattle herds. In all 10 herds, the animals learned to eat docks allocated in troughs. In two of the herds, the animals learned to crop docks directly in the field. In one of these herds, the animals continued to crop the docks two years after the end of the experiment. There is no clear conclusion as to why the animals in two of the herds learned to crop docks directly in the field when the animals in all herds learned to eat docks in the troughs. The results indicate that the number of available docks and the fact that a flock leader (or that one of the highest-ranking animals) shows obvious interest in the docks may be important to whether the cattle themselves begin to crop the docks in the field.

Cow-calf contact in full bloom at AU in Foulum

A new project at Aarhus University will promote organic veal and beef production based on a system where two calves go together with a "suckler-aunt" until about 6 months of age.

The aim of a new Organic RDD6 project called "GrOBEat" is to develop a more sustainable strategy for organic veal and beef production. GrOBEat wants to develop a system based on grazing during the summer season and feeding with clover grass silage during the winter season. From June to September/October, the calves will be on pasture together with their "suckler-aunts" until they are about 6 months old. From weaning until slaughter at 8, 16 and 24 months, respectively, they are fed grass-based feed in the barn and graze during summer.

The project focuses on sustainability in the organic veal and beef production. The aim is to develop products that live up to consumer demands regarding consumer satisfaction and pleasure for the product they eat as well as climate. The project is coordinated by ICROFS and is funded by the Green Development and Demonstrations Programme (GUDP).

Using probiotics for piglets is a promising strategy

In all probability, early allocation of probiotics to piglets can contribute to strengthening the pigs' immune system so that they become more robust. This is what new research from Aarhus University indicates.

Gut-related diseases in piglets are a big challenge for the Danish as well as the global pig industry both because reduced productivity and health cause a lower bottom line and because the use of antibiotics for treating these diseases poses a risk for developing resistance to antibiotics.

A good beginning of life is the key to success

As maturation of the immune system is directly affected by the presence of bacteria in the intestine, it is interesting to examine whether administration of healthy bacteria, like probiotics, can make the pig more robust so that it can cope with weaning without developing diarrhoea. Therefore, the overall purpose of a PhD project conducted at Aarhus University was to develop a probiotic product which can be administered early in the pig's life with the objective of developing a healthy ecosystem in the intestine with a long-term positive effect.

Specially selected probiotic strains prime the pig's ecosystem

In the project, four probiotic strains, which complimented each other's positive effects, were selected for a product targeting newborn piglets. Early inoculation of the probiotics, consisting of the strains *L. rhamnosus, E. faecium, B. breve* and *B. longum subsp. infantis*, was examined in two animal experiments:

1. The first experiment focused on the effect of early inoculation of probiotics to piglets on the gut microbiota composition and immune modulations.
2. The second experiment examined the effect of administration of probiotics before weaning in piglets challenged with the pathogenic E. coli bacterium ETEC F18 post-weaning.

Among others, the results showed that early inoculation of probiotics to piglets changed the microbial diversity after weaning and after cessation of the probiotic administration. Furthermore, the pigs that were inoculated with probiotics before weaning and inoculated with the pathogenic E. coli bacterium (ETEC F18) after weaning had a lower prevalence of diarrhoea.

Increased robustness with probiotics

The study concludes that early inoculation of probiotics for piglets is a promising strategy increasing the piglet's robustness towards weaning thus reducing the susceptibility to gut-related diseases after weaning. Future studies will examine more practical methods of application so that the concept can become an advantageous and practical solution for the farmer.

The PhD project is conducted as a cooperation between Aarhus University and Chr. Hansen A/S and is funded by Innovation Fund Denmark and Chr. Hansen A/S. Results from the PhD project are included in a patent application.

The photo illustrates oral allocation early in the piglet's life. Photo: Research Centre Foulum, Aarhus University.

Research led to improved conditions for cull sows

Research results from a Master thesis at Aarhus University have led to improved conditions for cull sows at Danish Crown's sow slaughterhouse in Skærbæk.

Each week, more than 6,000 sows are slaughtered at Danish Crown's sow slaughterhouse in Skærbæk – one of few big sow slaughterhouses in Denmark.

After arrival, entering the slaughterhouse may be stressful to the animals and to cull sows in particular as they are more sensitive to transport stress than finisher pigs. This may be due to the fact that they are older, have increased prevalence of disabilities and because they fight more often during transport.

Calm conditions for animals and personnel

Recently, results from a Master thesis have led to changes at the slaughterhouse, ensuring that arrival and moving of sows towards the lairage pens are easier and calmer for both animals and personnel.

Veterinary surgeon Sanne Weinreich Christensen carried out the study when pursuing her Master's degree in "Animal Welfare in Primary Production" at Department of Animal Science, Aarhus University. Sanne W. Christensen works at Danish Crown, and data from the company are included in the thesis.

AU is part of a new project which will reduce the use of antibiotics for pigs by means of UV light

The research barns at AU Foulum will house a new project aiming at testing a so-called combination light which can minimise bacteria and virus in the barn environment. The project is led by Farmer-Light Holding and is funded by GUDP.

The use of antibiotics in pig production is still a challenge with regard to the risk of developing resistance. A new project (UVIBA) will therefore contribute to increased welfare in pigs and decrease the use of antibiotics by means of a specially developed LED light source. The light source has a certain composition of light waves that can reduce the prevalence of health-impairing microorganisms in the animals' surroundings in the barn. It is a matter of UVA and UVB light waves which, besides increasing the hygiene in the barn, are also expected to increase the natural synthesis of D3 vitamin in the pigs thus increasing pig health.

Introductory laboratory experiments have resulted in an obviously limiting effect on the number of bacteria and virus by use of UV light. Therefore, it will be interesting to see whether this effect is also retrievable in pig pens. At Aarhus University, Senior Researcher Nuria Canibe leads the part of the project which is about testing in the experimental barns.

The experiment at AU Foulum

- We begin with examining the effect of light on the level of pathogenic microorganisms in the barn and in the pigs, says Nuria Canibe.

Afterwards, the light source will be tested in the farrowing barn with sows and piglets as well as in the grower barn at AU Foulum. Here, we will examine the pigs' gut microbiota and immune response. Doing this, we obtain direct numbers of and knowledge about how much the light source reduces the microorganisms in the barn environment and which direct effect the light has on the pigs. DTU is responsible for measuring and verifying the doses used for illuminating the pigs during the experiment. The University of Copenhagen is responsible for measuring the number of various bacteria and virus on the pigs' skin, the pigs' nose and the equipment while Aarhus University among others follows the pigs' D vitamin status, immune response and the effects in the gut, and coordinates the experimental studies of pigs.

The perspective is that the LED light will contribute to increased animal welfare via a reduced incidence of disease thus reducing the use of antibiotics in pig production.

Read more at
dca.au.dk/en

Pilot project to support the transition to cage-free systems for laying hens in the EU

In 2021, the EU project "Best Practice Hens" was initiated. This project aims to collect knowledge on best practices regarding husbandry of pullets and adult laying hens in cage-free systems and to support the transition to cage-free systems for laying hens in the EU.

In the first year of the project, best practices will be developed for keeping pullets and laying hens in cage-free systems, i.e., in barn, free-range and organic systems. To collect input for these best practices, four countries are included in which a high percentage of birds is already kept in cage-free systems (The Netherlands, Germany, France, and Denmark). Also, information on the specific situation in four target countries, that are still in transition, will be collected to adapt the best practices to their local conditions (Belgium, Spain, Portugal, and Poland).

In the second year of the project, the best practices will be presented partly at meetings with physical attendance in the four target countries and in Brussels and partly on social media. The collected knowledge on best practices for management and housing will specifically focus on how to obtain good animal welfare, economy, and sustainability in cage-free systems. Stakeholders from the egg industry, European farmers' organisations and NGOs will be involved in the project from the beginning.

"Best Practice Hens" has been funded by EU and runs until May 2023.

Horses' curiosity increases their learning ability

Curiosity and learning ability go hand in hand. We know this from humans and non-human primates, but for the first time it has now also been scientifically demonstrated in horses in a new study conducted at Aarhus University.

Research at Department of Animal Science, Aarhus University, has demonstrated that horses displaying curiosity towards novel objects also are the ones doing the best job when learning new tasks. These are the results from a study examining the coherence between horses' curiosity and learning ability. Behind the research is Associate Professor Janne W. Christensen who has conducted research in stress biology and learning ability in horses for many years. In previous studies at Aarhus University, she has demonstrated that fearfulness has a negative impact on learning ability and performance ability.

– Our new results show that curious horses did better in two different learning tests compared to non-curious horses. And if a horse was curious when being a foal, this was most likely also the case later in life", says Janne W. Christensen. According to Janne W. Christensen, the result is interesting for any further research but also for everybody handling horses: "This is extremely important knowledge when speaking of practice because we are dependent on the horse's learning ability when it comes to the training of and our relation to the horse, she explains.

Black soldier flies will contribute to green transition

Protein production from insects will be optimised with help from researchers at Aarhus University and corporation partners. This will be achieved through the GUDP-funded project EntoFeed.

In recent years, the interest in insect production as part of the green transition for a sustainable agriculture has been strongly increasing. Many insects can exploit biomass from residual products. For instance, black soldier flies have proven to be particularly productive on a large range of substrates from residual products. However, as soldier flies and other insects are recent additions to farmed animals, their production has not yet been optimised like in traditional farm animals.

The best composition of nutrients

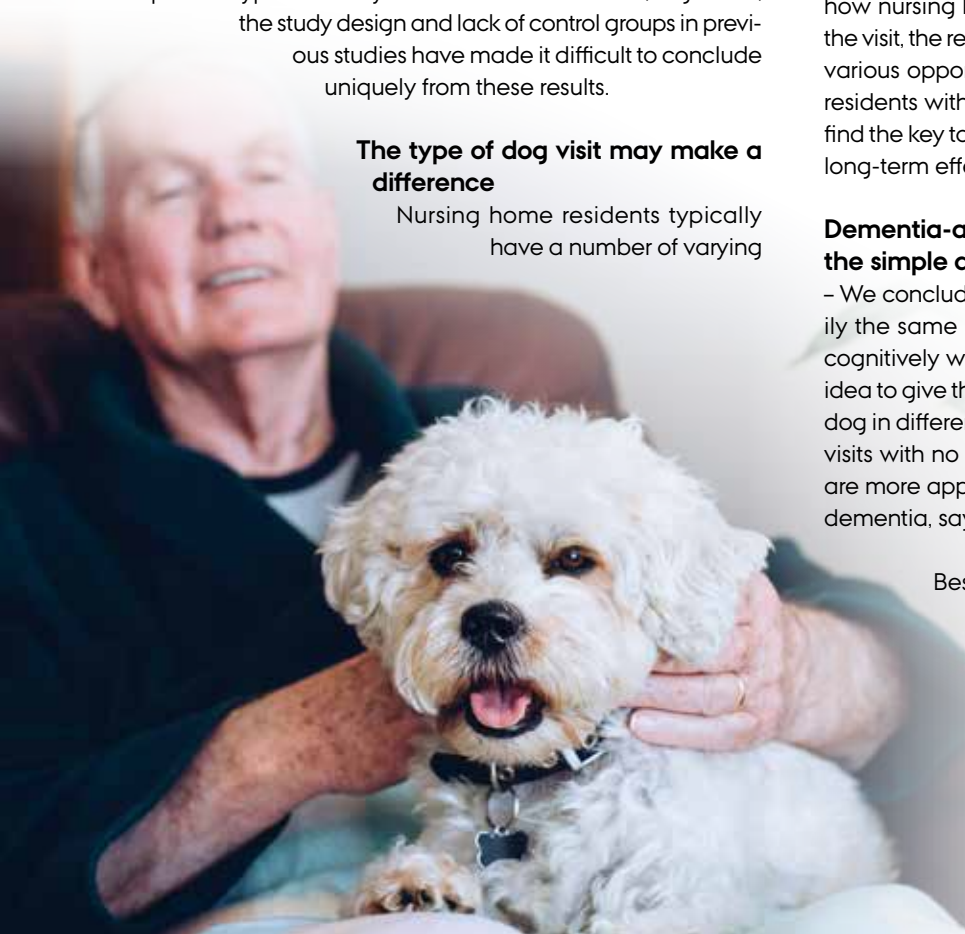
In a new research project funded by GUDP, researchers at Department of Animal Science at Aarhus University are going to work on optimising the diet for black solider flies so that the production is maximised at minimal feed use. On a longer term, the work will also include breeding using methods to improve the genetic inheritance of lines adapted to different residual substrates.

How do nursing home residents benefit the most from dog visits?

Nursing home residents with an advanced dementia benefit the most from simple dog visits where they are just together with the dog without doing any specific activities. However, for the most well-functioning residents, it may make sense to add activities which can stimulate for more interaction with the dog. This is what a new study from Department of Animal Science at Aarhus University indicates.

Dog visits have become a popular activity in many nursing homes in Europe. Several organisations around the world, like TrygFonden's Visiting dogs in Denmark, recruit voluntary dog owners and their dogs to give nursing home residents the opportunity of having animal contact.

In several previous studies, it has been studied how dog visits affect nursing home residents. Many things indicate that dog visits at nursing homes have the potential to be a good and positive type of activity to the residents. However, in general, the study design and lack of control groups in previous studies have made it difficult to conclude uniquely from these results.



The type of dog visit may make a difference

Nursing home residents typically have a number of varying physical and cognitive disabilities and impairments. In general, being engaged in everyday activities seems to have a positive effect on the residents' well-being. However, residents with severe dementia generally tend to participate less in such activities.

– Here, a visiting dog is a possible activity that may fulfil the very different needs and wishes from nursing home residents as regards how to interact and communicate socially, says Senior Researcher Karen Thodberg from Department of Animal Science, Aarhus University, who does research within the topic.

– But we need more knowledge in the area, especially if we want to identify which elements in the dog visits that benefit the nursing home residents the most, she clarifies.

Therefore, in cooperation with researchers in psychiatry and psychology from Copenhagen and Aalborg, respectively, she has conducted a study funded by Trygfonden aiming to see if the opportunity of an increased interaction with a visiting dog could have a positive effect and stimulate the residents to further activity during a dog visit. By observing how nursing home residents interact with the dog during the visit, the researchers obtain more knowledge about how various opportunities for interaction with the dog engage residents with different degrees of dementia and possibly find the key to better understanding the potentially positive long-term effects of having regular contact with a dog.

Dementia-affected residents benefit the most from the simple dog visits

– We conclude that the optimum dog visit is not necessarily the same for all nursing home residents. For the most cognitively well-functioning residents, it would be a good idea to give the resident the opportunity to interact with the dog in different ways. On the other hand, it seems that dog visits with no extra activity, thus focusing only on the dog, are more appropriate for residents with a more advanced dementia, says Karen Thodberg.

Besides observing what happens during the dog visit, the researchers have also conducted "before and after" measurements of the degree of depression and dementia, if any, in the nursing home residents. These results will be published later.

Read more at **dca.au.dk/en**

A new technology for surveillance of broiler chickens' welfare

Aarhus University takes part in a large international project aiming at developing a system for surveillance of welfare in poultry by means of camera technology and advanced image analysis.

The intensive production of fast-growing chickens in very large flocks can negatively affect welfare and cause leg problems, hock burns and footpad dermatitis.

The Department of Animal Science at Aarhus University takes part in the large international poultry project, SMART Broiler, with the purpose of ensuring continuously good animal welfare in broiler chickens.

The project primarily focuses on leg health and gait scores as well as on creating a system which can warn the farmer early in case of risk factors such as wet litter. Furthermore, the project will focus on the level of fearfulness in the flock and the animals' patterns of movement, level of activity and natural behaviour.

The project is based on Precision Livestock Farming techniques using information and computer technology for continuous automatic surveillance and management of livestock herds within a large number of focus areas.

- When conducting welfare assessments in poultry flocks, behaviour is a key indicator. Traditionally, welfare assessments are conducted by trained personnel in the poultry barns. However, manual assessment can only add occasional evaluations of the animals' welfare, says Anja Brinch Riber, who is part of the project.

SMART Broiler is funded by the American research foundation Foundation for Food and Agricultural Research (FFAR) and McDonalds, and besides Denmark, the project includes partners from the Netherlands, Belgium and USA.

Aarhus University is responsible for the part of the project, which is to ensure that the collected image and video material will be linked with the existing indicators of health and welfare in broiler chickens.

Four animal welfare researchers from AU contribute to revision of EU's legislation

Research in animal welfare is one of the focus areas in the Department of Animal Science. Therefore, it is not coincidental that four animal welfare researchers from the department are present at the revision of EU's animal welfare legislation.

The work takes place in the expert groups of the European Food Safety Authority EFSA, and the four researchers will contribute to ensure that the most recent research-based knowledge is available when the European animal welfare legislation is being revised in the years to come.

Anja B. Riber contributes to the working group on broilers and the working group on ducks, geese and quails. Likewise, Margit Bak Jensen contributes to two working groups, one on calves and one on dairy cows, whereas Peter T. Thomsen contributes to the working group on transport of animals. Mette S. Herskin chairs the working group focusing on transport of animals that are kept loose during transport: horses, cattle, sheep, goats and pigs.

FOOD QUALITY AND CONSUMER BEHAVIOR

The Ministry of Food, Agriculture and Fisheries of Denmark (FVM) and Aarhus University (AU) have entered into an agreement on the provision of research-based policy support within food quality and consumer behaviour.

The agreement specifies three scientific focus areas in relation to which AU/DCA carries out research and policy support activities:

1. Raw materials and food quality
2. Consumer behavior and food preferences
3. The importance of food and meal habits to health and sustainability

You can find the agreement at **dca.au.dk**

Research-based policy support within the area is primarily carried out by researchers from the Department of Food Science and the MAPP Centre, Department of Management.

You can read more about our activities in the following.

Aarhus University gathered Nordic competences within cultured meat

A need exists in the Nordic countries for increased coherence between research and production when it comes to cultured meat. In the spring of 2021, an online workshop gathered actors from all over the Nordic region to discuss the development of the research area. The Nordic Joint Committee for Agricultural and Food Research (NKJ) network "Cultured Meat – Nordic Take", headed by Department of Food Science at Aarhus University organized the event.

- We possess extensive knowledge in the Nordic region, and now we have to apply it in practice in relation to startups, who can initiate production. We are close to initiate actual steps. At the meeting, there was consensus that even though we may be slow compared to other countries, it is not too late to join the trend. We have multidisciplinary research, high-technology production, several biotech companies and a very high level of education in Scandinavia. In addition, our consumers are very environmentally and climate conscious; and as far as we can see, climate consideration is the most important incentive for consumers to choose cultured meat, says Associate Professor Jette Feveile Young, Department of Food Science at Aarhus University and head of the "Cultured Meat – Nordic Take" network.

Within a few years, we expect that cultured meat will be available in the high-end market such as better restaurants.

We hope to organize more events in relation to cultured meat, and Department of Food Science will contribute its efforts in the Nordic network.

Netværket har lavet en LinkedIn-gruppe, hvor interesserede kan holde kontakten og dele relevant materiale. Gruppen hedder "Cultured Meat – Nordic Take".

See the group on LinkedIn – **click here**

Super clusters and AU's focus on industrial co-operation will lift the growth segment in food and bioresources

Increased knowledge to companies, more successful startups and new sustainable solutions within food and bioresources. These are the goals to be achieved via a new cooperation agreement between Food & Bio Cluster Denmark and Aarhus University's focus on industrial cooperation.

In its capacity as a national super cluster, Food & Bio Cluster Denmark is an obvious cooperation partner in Aarhus University's efforts to strengthen innovation in private and public companies. The cluster is a merger of four organizations and together they have huge experiences with innovation in food and bioresource companies as well as entrepreneurial development. Aarhus University is a leader within research in foods, bioresources, agroecology, animal science and bioscience.

As a new national super cluster expected to create innovation and growth within foods and bioresources, Food & Bio Cluster Denmark can identify the excellent ideas found in Aarhus University's entrepreneurial environments and make them grow.

- Far more companies should benefit from the research-based knowledge, which is the university's hallmark, and national clusters are obvious partners in these efforts. At the same time, we want to support the new trade promotion structure. Thus, this is the first, but hopefully not the last, agreement on cooperation between the new clusters and Aarhus University's focus on industrial cooperation, says Lone Ryg Olsen.

Read more at Foodbiocluster – **click here**

News in brief

Researcher wants to turn stale bread into packaging material

Too much bread ends up in the trash, but what if, instead, it could return to the supermarket as high-performing and fully biodegradable packaging?

Is it possible to fight food waste, while creating a sustainable packaging material? Assistant Professor Mario M. Martinez, Department of Food Science at Aarhus University, will take up the challenge.

He has just received 2.9 million DKK from the Independent Research Fund Denmark for a research project the purpose of which is to provide chemo-mechanical methods to turn stale bread waste directly into biodegradable materials with high moisture resistivity for food packaging applications.

- Bread waste comes in as second type of food waste that has the most negative environmental impact. Some uses have been considered for the reutilization of bread waste, such as animal feed, and a source of fermentable sugars. Nonetheless, the bread components have huge potential for utilization as something of higher value than a mere source of fermentable sugars: as building blocks of future bio-based and biodegradable materials. Therefore, it would be a much more efficient use of resources, if we took advantage of the polymeric nature of the bread components instead of breaking everything down to sugar, he says.

- Not only will this project be converting bread waste directly into packaging material for the first time, but it will also be groundbreaking in doing this by means of green chemo-mechanical methods using naturally-occurring organic acids and organo-catalysts, both of which are found in foods – organic acids can be found in fruits. Therefore, everything in this project is fully biodegradable and made from edible compounds, Mario M. Martinez emphasizes.

The aim for the next three years is to create prototypes that can function as high-performing and fully biodegradable packaging materials – and to achieve an understanding of the structure and the physicochemical properties of these prototypes.

- With this new and innovative project, we will be able to fill a knowledge gap by explaining the direct conversion of the stale bread matrix into 100 % biodegradable films with good water resistivity and mechanical properties - and thereby to deliver a scientific breakthrough, Mario M. Martinez concludes.

Grass to replace plastic in take-away food packaging

Soon, packaging for take-away foods might be completely based on local, sustainable materials instead of fossil¬-based products.

Grass fibres may replace plastic as a 100 % biodegradable and disposable packaging material for take-away food. This is the goal of the new innovative project SinProPack, which aims to develop a sustainable alternative to the disposable plastics currently used for packaging.

- Disposable packaging made from grass brings a lot of environmental benefits. The packaging will be 100 % biodegradable, so if someone accidentally drops their packaging in nature, it will decompose naturally," says Centre Director Anne Christine Steenkjær Hastrup, the Danish Technological Institute, who is coordinating the project.

Every year, Denmark consumes more than 10,000 tonnes of packaging for take-away food and drinks. Replacing 10,000 tonnes of disposable plastic with a corresponding quantity of bio-based and biodegradable packaging will reduce carbon emissions from packaging production by approx. 210,000 tonnes CO2 annually.

Green biomass is an easily accessible resource in Denmark, and green biorefining for protein production is already of considerable interest because of the proven high biomass yields, environmental effects and the potential to use untapped biomass from unproductive low-lying areas such as meadows and other marginal areas.

- After we harvest the grass and extract the protein to be used for animal feed, we can refine and pulp the grass fibres for cellulose and produce packaging. In this way, we can use and up-value a side stream from protein production and create added value, says Assistant Professor Morten Ambye-Jensen from the Department of Biological and Chemical Engineering at Aarhus University.

Fibres constitute approx. 70 % of the grass fed into biorefining after protein has been extracted.

Within the framework of the project, the researchers will look at both grass and clover as fibre sources, as clover will be the primary biomass to be used in future green biorefineries. The project has received 3.3 million DKK in funding from the Green Development and Demonstration Programme, GUDP.

Read more at dca.au.dk/en

Researchers want to make sustainable choices and disposal of food packaging easier

Consumers are confused about how to dispose food packaging in a sustainable way. In a new project, researchers want to change this with science-based campaigns, providing the information needed to make the right choice.

Researchers want to make it easier for consumers to make the right choice with science-based campaigns creating awareness and closing information gaps - and finally enabling the public to improve their disposal patterns at home and on the go. The project InFormPack is funded by the European Institute of Innovation and Technology (EIT Food), as a cooperation between Aarhus University and a number of international partners – as this is an issue relevant across Europe.

- There are so many different packaging types, systems for garbage sorting, guidelines etc. With this project, we want to focus on challenges that the Europeans face - and how we can address them with targeted information, says Niki Alexi from Department of Food Science, Aarhus University.

Within the framework of the project, questionnaire surveys have been completed in the UK and Greece in order to identify the questions consumers may have as to sorting waste and packaging. The purpose was to prepare campaigns that address relevant questions on food packaging. Next, experts were asked same the questions to ensure that the campaigns were based on facts and knowledge.

Campaigns

- Our studies demonstrate that consumers feel that fruit and vegetables are excessively packed. However, packaging can reduce food waste, as it can make food last longer in retail and at home. So what is best: packed or unpacked? It depends on a combination of the packaging elements, the food characteristics, the supply chain characteristics as well as other aspects. Therefore, we have developed a campaign theme that addresses: "Why do we package fresh fruits and vegetables", says Niki Alexi.

Project participants were asked about the challenges they face in relation to both the choice and disposal of food packaging, because these are closely interconnected.

- Consumers are confused as to the "correct" disposal – sorting as well as whether to wash the packaging before recycling. To solve this dilemma, we have prepared two campaigns: one that explains the recycling symbols on the packaging, and another campaign that is concerned with cleaning and washing prior to recycling, says Niki Alexi.

An important aspect of the project is to make consumers engage with the information given as this will this will improve the likelihood of the campaigns having a positive impact on consumer behaviour.

- In order to ensure that our campaigns have a positive impact on behaviour, we tested them in a representative section of the target groups (N~500, GR and UK). The study demonstrated that – having watched the campaigns – more than 88 % of the participants stated that they would be much more aware of sustainability when sorting garbage, says Niki Alexi.

Digital food fotography may make us eat healthier

We view, create and share pictures of our food like never before. In a new literature review, researchers suggest that the phenomenon #foodporn, if used wisely, may help us develop a healthier and more satisfying relationship with food.

Have you ever taken a photo of your meal and shared it with followers, friends and family?

On Instagram and other digital communication, it is becoming increasingly popular to participate actively in food content creation instead of mere passive consumption. Appetizing food images – commonly referred to as #foodporn – has become an important part of our digital food experience. One might ask whether this influences our actual eating behaviour, and – if so – how?

This is the topic of a new literature review by researchers from Aarhus University:

- Our view is that food photography, combined with a selective use of food-related digital media, may contribute to healthy body weight management and enhanced meal pleasure, says PhD Student Tjark Andersen from the science team Food Quality Perception and Society, Department of Food Science.

Watching images of food influences appetite

This comprehensive study concludes that watching images of food may induce reactions similar to watching real food. While a couple of food photos may stimulate appetite, then several photos may induce feelings of satiety. However, this satiety is restricted to the specific food category in question: watching photos of salty crackers may reduce the appetite for fries, but not reduce the appetite for cookies or candy.

If used wisely, this impact of our satiety has the potential of positively influencing our eating behaviour.

Food photos affect attention and pleasure

It is the intention to photograph itself that directs attention towards valuable visual aspects of an experience and engaging in food photography can therefore both increase the eater's attention on the food and amplify the pleasure of eating.

- This effect seems to depend also on the consumption goal, for example, whether people, at least implicitly, eat for pleasure or for health. Like any other behavior, eating is goal-directed. Only when the meal is congruent with the consumption goal does photography lead to increased enjoyment, says Tjark Andersen.

Further investigation of the sharing of food photos

While the phenomena of viewing and creating food photography are underpinned by research, the eating behavioral effect of sharing food photos has yet to be studied directly:

- We can only speculate as to how the sharing of food photography via social media may influence eating behavior. Existing research in commensality and, more broadly, social psychology suggests that the sharing of food photography could negatively influence food choice and eating pleasure. An example of this is seen in relation to eating disorders, where people can digitally receive emotional support from peers - but, at the same time, social media amplifies the natural tendency for social comparison, says Derek V. Byrne, leader of the science team Food Quality Perception and Society:

- Furthermore, research has demonstrated how the mere intention of taking and sharing photos may reduce the enjoyment of the meal experience compared to taking photos for personal use, as this may make people more self-conscious. Further research is required to study the impact of sharing food photos.

Utilising our senses is critical to the design of future healthy foods

Sight, smell, taste, touch, or hearing – all our senses are at play when we perceive and respond to food products, and finally when we make the food choice. This is the core of sensory science, which can be used to make our food choices healthier. The innovative research in the field carried out by Aarhus University is featured in a new book, edited by Professor Derek V. Byrne from the Department of Food Science.

How does brewing temperature influence the taste of espresso? Can suger-reduced products be just as sweet? – And does sleep curtailment affect our hedonic responses to liquid and solid food?

These are some of the questions answered in a new book edited by Professor Derek V. Byrne from the Department of Food Science at Aarhus University. The book includes key chapters from the Food Quality Perception & Society Science Team, which emphasizes that acceptance and preference of the sensory properties of foods are among the most important criteria for determining food choice and as such are critical to food design for the future. Professor Derek V. Byrne explains:

- Our sensory perception, our response to food products and finally our food choices are influenced by a myriad of intrinsic as well as extrinsic factors. The major question is how do these factors affect our acceptance and preference for foods, both in themselves, and in combination in various contexts? Which factors generally play the largest role in how we perceive and behave towards food in everyday life? - And how can these factors be utilized to make our food choices healthier? These are the fundamental research questions in the Food Quality Perception & Society Science Team and the topic of the new book.

Sensory science can reduce our sugar intake

The book is, entitled "Consumer Preference and Acceptance of Food Products" and is published by MDPI Foods. It brings together articles, which encompass the wide scope of multidisciplinary research in sensory science For Aarhus University this research comprises innovative research related to sweetness, which may potentially help reduce our sugar intake, one of the major contributors to the current obesity epidemic.

- The perception of sweetness is not just a matter of the amount of sugar added to a food product. The experience of sweetness depends on several factors that both concern the product itself as well as the context in which the product is consumed. This includes food-intrinsic factors, such as product colour, aroma, texture and viscosity, and food-extrinsic sensory factors, such as visual, auditory, olfactory (relating to the sense of smell) and tactile (relating to the sense of touch) properties of product packaging, serving ware, background music, ambient lighting, temperature and aroma, Derek V. Byrne says and adds:

- An understanding of the interaction between these different factors as well as their relative importance to our perception of, and not to mention our behaviour towards, food and drink, may help us contribute to the healthier food choices of tomorrow.

Researchers want to improve the quality of plant drinks

The demand for plant drinks is increasing, but how is the quality of their proteins? Researchers will investigate this within the framework of a new project.

In recent years, a wealth of plant drinks have found their way to the shelves in Danish supermarkets as part of the growing selection of plant-based foods often included in a more climate-friendly diet.

But what about the protein quality in the new product category? Do we get what our bodies need when we increase consumption from adding a bit of rice drink in the morning coffee to pouring it on our oatmeal?

Within the framework of a new research project, researchers from Department of Food Science at Aarhus University will explore the world of plant drinks with the purpose of investigating the connection between processing and plant protein quality in various plant-based drinks to help ensure that future products will have the best possible protein quality.

- Plant drinks are exposed to harsh processing procedures, during which the protein components are extracted from raw materials such as almonds or rice. In addition, the plant drink is heated at high temperatures to ensure that no bacteria are present. This means that the product has to go through many procedures before ending up with the consumer, and currently we do not know how this will affect the protein quality, says Post doc Anne Vuholm Sunds.

- When we achieve more knowledge on the protein quality in different plant drinks – including how protein quality is affected by the processing – we can find out which buttons to push in order to achieve the highest possible protein quality in the finished product.

Can we absorb proteins from plant drinks in our bodies?

- We are already able to measure the protein content in plant-based drinks, and this information is available (on the packaging) to the consumer. However, the protein quality is yet unknown and it is still uncertain whether or not we are able to absorb all the important amino acids from the proteins, when digested, in the same quality as found in the plant drink, says PhD student Ida Schwartz Roland:

- Thus, it may be very difficult for consumers to find out whether or not they get the sufficient amount of proteins if plant-based drinks are a substantial part of their diets. In addition, we want to contribute to the development of a gentle treatment of plant-based proteins included in new products.

The researchers' hypothesis is that the more harsh a processing method is, the more the proteins will change, and the poorer the quality will be; they will be poorly digested and absorbed into our bodies. By being able to measure these changes, it will be possible to identify new, gentle methods of pre-processing food proteins.

Once the product itself and its protein quality have been under scrutiny, the researchers will investigate whether and how our bodies digest those proteins. This will be done in the laboratory by simulating the digestive process, using enzymes such as those we have in the gastrointestinal system.

Can plant cell walls and flavonoids protect us against obesity and type 2 diabetes?

Mario M. Martinez has been awarded the prestigious Sapere Aude research grant of 6.2 million DKK from the Independent Research Fund Denmark. The grant will be used to explore interactions between plant cell walls and flavonoids found in most fruits and vegetables. This knowledge can protect us from the negative effects caused by sugars.

Starches and sugars are two well-known components in the development of obesity and type 2 diabetes. However, it is less known how the small chemical compounds flavonoids, which are found in nearly all fruits and vegetables, and which are famous antioxidants, contribute to protect us from the negative effect of sugars.

Mario M. Martinez from Aarhus University will investigate this in a new research project.

He has just been awarded the prestigious Sapere Aude research grant of 6.2 million DKK, which is given by the Independent Research Fund Denmark to some of Denmark's most promising research leader talents.

- Too many people miss out on too many years with good quality of life due to diseases related to high blood sugar levels. We cannot solve the problem by removing carbohydrates from our diets as we need these for basic metabolic functions; nor can we rely heavily on people's will power alone as this will benefit only those with sufficient time, money and cognitive and psychological resources to follow a strict diet. Therefore, we urgently need solutions that are easily accessible to everybody. An understanding of the complexities in flavonoid bioavailability and metabolism may be very promising for our metabolic health, he says.

Solving the mystery of cell wall bindings

Existing studies of flavonoids have shown a positive impact on insulin sensitivity and other factors related to the development of obesity and type 2 diabetes, but they have focused mostly on pure flavonoids extracted and refined from fruits and vegetables - and that is not how we find them in our food.

In reality, the flavonoids form part of complex interactions with polysaccharides, including those from the plant cell wall, during various forms of processing - either in the food industry or during our digestion, for example by heating or chewing.

These interactions may affect the stability and functionality of the flavonoids, most of which are sensitive to high temperatures and will be partially or completely degraded during cooking.

- We have to understand the ways in which the various flavonoids are bound to the different polysaccharides, if we want to change the way our body utilizes sugars and starches – with the impact of flavonoids, Mario M. Martinez explains.

Using byproducts for sustainable solutions

If the project succeeds in demonstrating a significant effect of bound flavonoids, this might eventually encourage the food industry to up cycle side streams and thus contribute to a more sustainable food production system.

- A considerable amount of fruits and vegetables never reach our plates, but the technology development has the potential to up cycle these and help us avoid food waste. We know, for instance, that pomace from wine production contains flavonoids. It would be fantastic if we could utilize this and recognize this side stream for the gold that it is, Mario M. Martinez concludes.

Why do foods containing the red colorant norbixin fade?

The seeds from the exotic annatto tree contain the red colorant norbixin, which is used to add color to a wide range of foods, including cheddar cheese, but the colour tends to fade. Researchers from Department of Food Science at Aarhus University are close to understanding the mechanisms behind the loss of colour.

For centuries, the red seeds from the fruits of the annatto tree have been used to color foods, hair and skin. The seeds contain the red fat-soluble colorant bixin as well as the water-soluble version norbixin.

Today, the natural colorants are primarily used to add color to a wide range of foods such as dairy products like cheddar cheese. However, its use is associated with challenges for the food technology:

- Consumers as well as the food industry have a strong wish to replace artificial colorants with natural alternatives, and the use of the colourful seeds from the annatto tree seems to be an obvious solution. And thanks to its water-soluble properties, norbixin is one of the most widely used natural colorants in the food industry. However, the color is more likely to fade compared to artificial colorants. In order to improve this, we need to understand the mechanisms behind the fading, says Postdoc Anders Hauer Møller, Department of Food Science.

In cooperation with the ingredient company Oterra (used to be part of the Chr. Hansen Group), researchers from the research team Food Chemistry and Technology at the Department of Food Science have focused on the problem - and the efforts have provided exciting results.

Chain mechanisms may be part of the answer

- We have identified a number of chemical compounds that have occurred during storage of norbixin in aqueous solutions. These compounds may be divided into two groups: compounds with a lower mass than norbixin and compounds with a higher mass than norbixin – in other words, degradation products and oxidation products. And the latter is of utmost importance in this context, says Anders Hauer Møller, and he elaborates:

- In our study we were able to detect norbixin with a considerable amount of oxidations. And therefore, we assume that the oxidation of norbixin involves a chain reaction mechanism, during which first one oxidation on norbixin is initated, which then reacts with a new norbixin, or perhaps the same norbixin, and so on. This is completely new knowledge.
The researchers examined samples stored in light and in the dark:

- Much to our surprise, we do not see any major differences in the oxidation products found in the different samples. However, we can see that light accelerates the process during which oxidation products are formed, says Anders Hauer Møller.

Vitamin E can slow the development

The researchers already have an idea of how to stop the chain reactions that occur during oxidation:

- We know from previous studies that Vitamin E is an effective chain-breaking antioxidant. Adding Vitamin E to foods with norbixin may be the solution, says Anders Hauer Møller.

Read more at **dca.au.dk/en**

Plant-based dye from carrots can replace synthetic color in foods in the future

Researchers from e.g. Department of Agroecology at Aarhus University have identified a method to activate mechanisms in orange carrots in order for them to produce more anthocyanin dye, which may replace synthetically produced dyes in food products. This provides new opportunities to replace synthetic dyes with plant-based natural dyes in the food that we eat.

Together with a group of researchers, Professor Henrik Brinch-Pedersen from Department of Agroecology at Aarhus University has investigated the possibilities of replacing synthetic colorants with natural colorants from carrots. The colorant found in purple carrots is known as anthocyanin.

The orange carrots that we know from our gardens do not contain anthocyanins, whereas the purple carrots do. The problem is that these are much more difficult to grow.

- Purple carrots do not give a high yield. This is a problem as we need the dye in huge quantities. The obvious solution would be to make the orange carrot produce anthocyanins. And we have found a way to do just that, says Inger B. Holme, Department of Agroecology.

Possibility to replace chemistry with plant-based material

The researchers have spent some years trying to find the best solution. In an article published in the Summer of 2020, the researchers explained that they had identified a method that would make ordinary orange carrots purple.

By comparing purple and orange carrots the researchers found that orange carrots still have the genes for anthocyanins – that is, parts of the machinery is lying latent in them, but they simply lack what it takes to kick-start the process of reading them.

Two missing genes

However, research efforts did not stop here. Even though the researchers found the mechanism in orange carrots, they still needed to identify what was missing in order to make orange carrots produce the dye.

- In our initial research, we were able to point out the transcription factors (e.g. for reading the genes) that make carrots develop anthocyanin colour, and we demonstrated that these are missing in the orange carrots. Now, we have identified the purple carrots' own genes for regulation and transcription, i.e. those that are missing in orange carrots. This means that we can recreate them, insert them in the orange carrot and make it purple, explains Henrik Brinch-Pedersen.

Paving the way

- Now we know how to change the carrots' production of dye. The identification of genes involved in the biosynthesis of anthocyanin is a huge step forward. This paves the way for a future modification of orange carrots to produce anthocyanin with different colour shades and in sufficient quantities to be used in the food industry, says Inger Holme.

Can we produce nutritional and sustainable milk in the laboratory?

Aarhus University in Foulum leads a new and exciting project which is to form the basis for producing sustainable milk in the laboratory as an alternative to cow's milk. The project is funded by the Novo Nordisk Foundation.

For centuries, milk from dairy cows has been an important nutritional source for billions of people worldwide. However, recent years have witnessed an increasing pressure in relation to finding alternatives because 18 % of the total greenhouse gas emissions in the world derives from domestic animals. In Denmark, dairy cows account for approx. 75 % of the agricultural emissions of methane.

In-vitro biotechnology instead of dairy cows

Senior Researcher Stig Purup, Department of Animal Science at Aarhus University, leads a new research project: "What do we drink in 2030? In-vitro milk based on cultured cells."

The project will contribute to the development of biotechnology that will make it possible to produce milk outside the cow (in-vitro) – by means of laboratory-cultured mammary cells from a cow. This is to pave the way for a sustainable alternative to the traditional milk production without compromising the milk's nutritional content and health-related qualities.

Mammary gland cells from cows cultured in the laboratory In-vitro milk based on mammary cells in cultures can maintain the complexity found in natural cow's milk. Mammary cells are the cells in the udder responsible for the secretion of milk. By cultivating and inducing lactation (lactogenesis) in these cells in a laboratory, the cells will be able to produce complex milk components equivalent to the valuable nutrients and bioactive components which cow's milk usually contains, explains Stig Purup.

However, this type of milk production has several challenges. "Therefore, it is crucial that we generate the basic knowledge on how to develop and optimize the biotechnology for production of in-vitro milk based on mammary cells", says Stig Purup.

Focus areas of the project

The project will generate knowledge for developing a new biotechnology – a so-called 3D biosynthesis platform for in-vitro milk production based on mammary cells cultured in the laboratory.

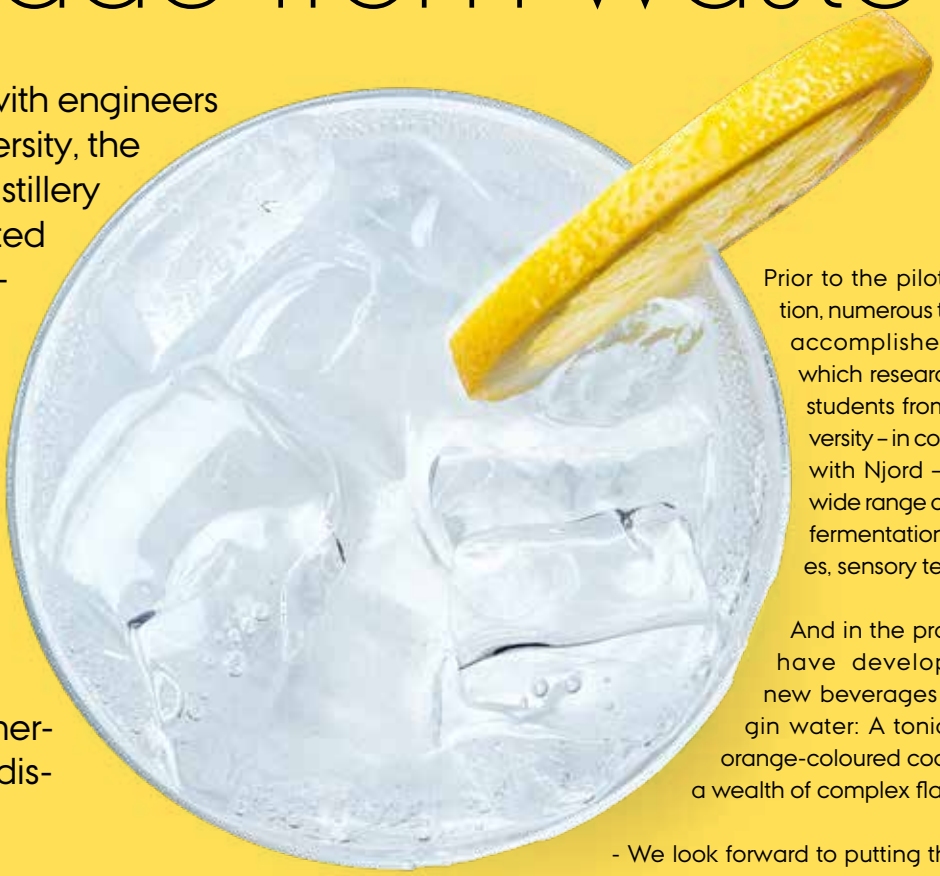
The researchers expect that the results of the project will contribute significantly to research in sustainable food products and be essential in the further development of biotechnology. Together with scalable cell culture techniques, it will support the future industrial productivity of in-vitro milk.

- In the long run, we expect that this biotechnology will have significant impact on food production by providing a new view on milk production and dairy products in-vitro. By offering consumers sustainable and climate-friendly alternatives, and thereby reduce the dependence on milk production from dairy cows, it will eventually contribute to reduce the greenhouse gas emission from the agriculture", concludes Stig Purup.

Read more at **dca.au.dk/en**

Now you can have a gin and tonic made from waste

I cooperation with engineers at Aarhus University, the small Aarhus distillery Njord has created innovative beverages using the company's residual products: "It's a fantastic way of creating high-value products out of something that would have otherwise just been discarded."



Together with e.g. Aarhus University, the Njord distillery initiated the project "Sustainable Ginventions" with funding from Future Food Innovation, FFBI, and the innovation network for environmental technology, Inno-MT.

The purpose of the project was to examine residual water and flavour fractions, and to try and find out how to optimally recycle both parts and use them in new products. And also to show that it is actually possible and worthwhile to work with sustainable circular production, even when it comes to products designed for complex and exciting taste experiences.

- After we have distilled gin, we are left with a cloudy tea-like liquid that consists of water, a little bit of alcohol, and juniper berries, herbs and flowers. A very bitter, not particularly aromatic, herbal tea that we'd normally just throw out," says Jens Niklasson from Njord and he elaborates:

- After we noticed the amount of water, herbs and raw materials that were being dumped into the sewer, we thought it would be a good idea to use these residual products for some interesting products instead.

Prior to the pilot production, numerous tests were accomplished during which researchers and students from the university – in cooperation with Njord – tested a wide range of different fermentation processes, sensory tests etc.

And in the process, we have developed two new beverages from the gin water: A tonic and an orange-coloured cocktail with a wealth of complex flavours.

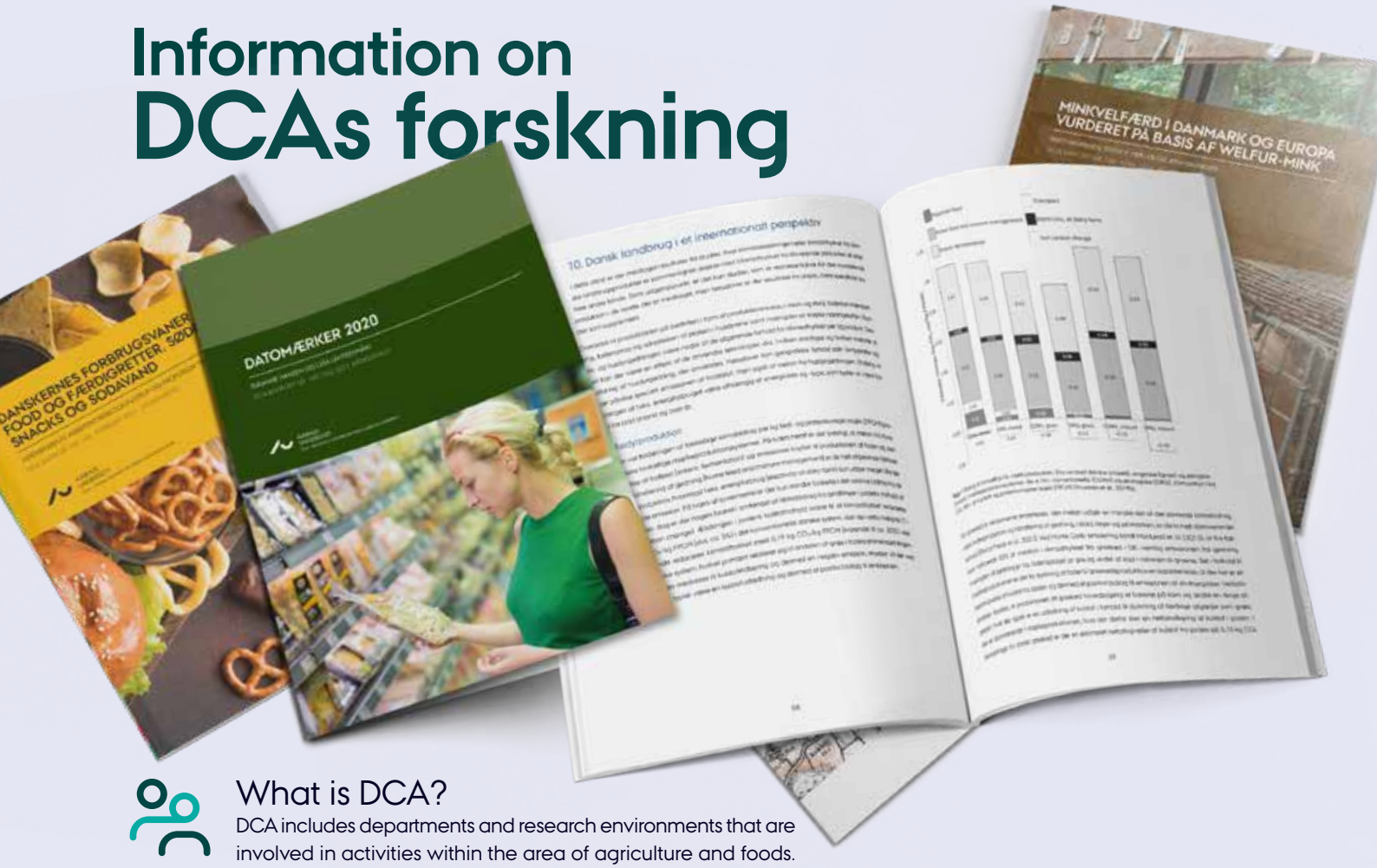
- We look forward to putting them both into full-scale production, says Jens.

Engineer Jesper Westergaard Kristensen runs the many facilities in the processing hall on a daily basis, and along with Njord he's today figuring out how to scale up the process to an industrial scale. He hopes that the project will inspire other companies to consider the benefits of knowing their waste streams and experimenting with them:

- Many small food companies lack equipment, knowledge and competences when it comes to their innovation processes. As a university, we can use the laboratory to lead the way, so that a company has a proof of concept to use as a starting point when it invests in equipment for industrial production," says Jesper Westergaard Kristensen and continues:

- We are invariably looking into a future where we have to rethink production chains, waste streams and residual products, and where a circular mindset is mandatory. Waste is a huge problem for modern food production, which is why this is a fantastic way of creating high-value products out of something that would have otherwise just been discarded.

Information on DCAs forskning



What is DCA?

DCA includes departments and research environments that are involved in activities within the area of agriculture and foods. Primarily:

- Department of Agroecology
- Department of Animal and Veterinary Sciences
- Department of Food Science
- Department of Biological and Chemical Engineering
- Center for Quantitative Genetics and Genomics
- MAPP Centre at the Department of Management

DCA reports

DCA publishes a series of reports that mainly communicates research-based policy support from DCA to the Ministry of Environment and Food of Denmark. Reports may also gather and communicate knowledge procured from research activities. The reports are available for free download at the DCA website at: dca.au.dk.

DCA newsletter

DCA issues a newsletter with information on current agricultural and food research, including new research results, policy support, education, events, and other activities. You can subscribe for the free newsletter at dca.au.dk

DCA on social media

You can find DCA on LinkedIn, Facebook and Twitter.

DCA research results

Research results are published in international, scientific journals – and more than 500 research publications are published each year. You can find the publications at the university's publication database (pure.au.dk).

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