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UNIVERSITY

DCA - DANISH CENTRE FOR FOOD AND AGRICULTURE

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DCA - DANISH CENTRE FOR FOOD AND AGRICULTURE

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

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By converting part of the agricultural area into more productive crops such as grass, agriculture can contribute to a reduction of nitrogen losses and greenhouse gas emissions. Senior scientist Uffe Jørgensen is heading AU's new interdisciplinary Centre for Circular Bioeconomy (CBIO). Read more on page 30.

Photo: Maria Randima Brauer Sørensen

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# The future is circular and biobased

Producing sufficient (animal) food for a growing middle class in places such as Asia and Africa is a global challenge. The challenge is complicated by an increasing demand for non-fossil energy and materials. Agricultural production must also make room for natural areas and reduce the environmental impact of nutrient losses and pesticides.

There is thus a significant need to think about innovative food and agricultural food systems that can combine consideration of the environment, increased resource efficiency and a stable food production. Research efforts therefore aim to find solutions - preferably by creating synergies, such as identifying crops and cultivation methods that can address the various challenges. One hypothesis is that we can produce more biomass per hectare with a reduced environmental impact, and thus cover the needs for food, feed and materials for other purposes.

Based on this, Aarhus University established the research platform BioBase in 2012. The purpose of this platform is to create an improved foundation for research in the development of sustainable production systems and competitive biorefining and energy technologies used to produce energy/fuels, new feed products and other high-value products, such as ingredients for the food industry.

As shown in this annual report from DCA - Danish Centre for Food and Agriculture, research within the framework of BioBase has demonstrated that cropping systems that include a larger proportion of perennial crops such as clover and grass may be beneficial to the environment, the climate and food production as a whole.

Biorefining can render these crops useful for high-quality protein feed, in particular for monogastrics. The pulp also has a high value as cattle feed because the pre-treatment process allows for an improved utilisation of nutrients in the rumen. We also expect to be able to produce "white protein" and other types of ingredients for use in the food sector as well as chemical components such as lactic acid, which can be made into polymers and, thereby, biobased plastics. Residual products can be used to produce biobased energy, e.g. in a biogas plant, thus ensuring the recycling of important nutrients back to agricultural production.

These efforts contribute to an increased agricultural income as well as displacement of fossil-based raw materials. Generally, a transition from a fossil-based economy to a circular and biobased economy holds significant social and industrial potential in which fossil-based raw materials are replaced with renewable plant and marine-based biomass and energy consumption is based on renewable resources, including sustainable biomasses and organic waste.



Photo: Jesper Røis

With a view to intensifying research efforts within the area, Science and Technology, Aarhus University, recently inaugurated the Centre for Circular Bioeconomy (CBIO) the purpose of which is to strengthen and coordinate interdisciplinary research and lay the groundwork for new, innovative solutions to major global challenges.

Activities in the biobased economy are one example of problem-solving research that originate from the research-based policy support provided by the DCA departments at Aarhus University to the Ministry of Environment and Food of Denmark.

When the Ministry requires research-based policy support, society - and in DCA's case - the agricultural and food sectors will gain new knowledge and insight concerning major and complex problem areas. This kind of research may be difficult to carry out in other contexts. This annual report illustrates the research efforts that constitute the foundation for Aarhus University's policy support in the agricultural and food areas.

The articles will provide examples of research within the areas of plant production, livestock production, engineering, food, and molecular genetics.

The articles describe recent research results, collaboration with commercial companies and agricultural advisors, and how our efforts contribute to strengthening the foundation for important public decision-making. We hope that the articles will inspire interest and understanding - in research as well as policy support.

We hope you will enjoy reading the report.

Niels Halberg  
Director, DCA - Danish Centre for Food and Agriculture



# About DCA – Danish Centre for Food and Agriculture

DCA – Danish Centre for Food and Agriculture comprises the departments at Aarhus University that carry out research activities in food and agricultural science. These departments include the Department of Agroecology, Department of Animal Science, Department of Food Science, part of the Department of Molecular Biology and Genetics and part of the Department of Engineering. In addition, DCA collaborates closely with the MAPP Centre at the Department of Management.

The activities in DCA are supported by a centre unit, which is in charge of tasks relating to research-based policy support, sector and industry cooperation, international cooperation and communication.

## Policy support

The DCA centre unit coordinates the agreement between the university and the Ministry of Environment and Food of Denmark (MFVM) regarding provision of research-based policy support within the areas of crop production, livestock production, and food quality and consumer behaviour.

Researchers from DCA-related departments provide research-based policy support ranging from short memorandums to extensive reports and knowledge syntheses. The agreement with the Ministry 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.

In addition, DCA is also obligated to regularly assess which areas may become topical for policy support. Such assessments can result in initiatives for carrying out research in areas in which there may be a need for further or new knowledge.

## Sector collaboration

An advisory panel contributes to organizing research and development collaboration with national users and collaborative partners. Members of the advisory panel include the Ministry of Environment and Food of Denmark, other authorities, industry representatives and a well-developed committee network.

The main task of the advisory panel is to provide advice on the centre's overarching supervision and strategy, including the relevance of research in relation to society's future needs for advisory services, national and international research topics, communication of knowledge to society and the framework for research-based policy support.

The advisory panel includes representatives from the Danish Veterinary and Food Administration, the Danish Agrifish

Agency, SEGES, Danish Crown, Organic Denmark, Arla Foods, COOP Denmark, the Confederation of Danish Industry and the Danish Society for Nature Conservation.

## International cooperation

Via its centre unit, DCA is in charge of a number of tasks in relation to international research efforts and policy support. On behalf of the Ministry of Environment and Food of Denmark, DCA attends to responsibilities in the European Innovation Partnership on Agricultural Sustainability and Productivity (EIP-AGRI), the Collaborative Working Group of Sustainable Animal Production, NordGen Council for Farm Animal Genetic Resources and Animal Task Force. Via its engagement in several ERA-Nets, DCA participates in a series of European research programmes. The centre also supports collaboration in relation to major applications to European research programmes, primarily Horizon 2020.

# Financing food and agricultural research

Different sources provide funding for research in food and agricultural science, and DCA's contract with the Ministry of Environment and Food of Denmark is the main income source. In 2016, DCA received 271.5m DKK to fund research-based policy support.

The grant from the Ministry of Environment and Food of Denmark allows DCA to attract and carry out research projects in collaboration with organisations and companies. This collaboration, together with grants from national funds and research programmes, was the main reason why the total research and development funding increased to more than 700m DKK in 2016.

DCA also participates in a significant number of international research collaborations at both Scandinavian and EU levels as well as in major global research consortia. International funding ensures increased research activities and allows DCA to provide research-based policy support at the highest possible international level.

# New agreement on research-based policy support

As of 2017, the Ministry of Environment and Food of Denmark (MFVM) has entered into a new four-year framework agreement with Aarhus University on the provision of research-based policy support. The agreement amounts to an annual amount of approx. 380m DKK, and comprises policy support provided by DCA – Danish Centre for Food and Agriculture and DCE – Danish Centre for Environment and Energy.

Contrary to services from private advisors, research-based policy support is based on research that is targeted the issues that are advised about. The concept of research-based policy support comprises policy support provided by the scientists in relation to actual commissions from the Ministry as well as the underlying research. In addition, the concept includes a series of tasks and services in relation to surveillance, support, etc.

The new framework agreement between MFVM and AU/DCA entails a number of changes compared to previous agreements. For instance, policy support efforts must be transparent and, as a starting point, all deliverables may be freely published unless they contain information that is encompassed by the statutory duty of confidentiality.

An important element of the new agreement is the description of quality control practices, according to which internal scientific quality control can be supplemented with international examination. The agreement further describes a model for the inclusion of scientific contributions from external parties. In addition, the authorities commissioning research from the university may also obtain scientific contributions or second opinions from other parties. Moreover, sector-related research is subject to the same quality control as other university research.

There are also several changes within the scientific framework of the policy support agreement. The previous agreement between MFVM and AU/DCA described 13 thematic areas within which DCA provided policy support based on underlying research. The new agreement comprises three performance agreements within the DCA-related area: crop production, livestock production and food quality and consumer behavior.

These performance agreements constitute the scientific framework of DCA's research-based policy support and describe the scientific effort areas. The actual tasks and projects agreed for the coming year are described for each effort area.

The performance agreements will be adjusted annually. This means that new tasks and projects will be included on a regular basis. In addition, acute tasks that the researchers must solve will occur from time to time. Table 1 gives an overview of the performance agreements and effort areas.

The agreements can be viewed on the DCA website (in Danish).

Table 1. Overview of agreements and scientific effort areas included in the framework agreement between MFVM and AU/DCA

Performance agreements	Effort areas
Plant production	Crop breeding and pollination, crop health aspects and crop protection, and Integrated Pest Management (IPM)
	Climate-smart production systems
	Fertilisers, standards and nitrogen prognosis
	Technology – agriculture and plant production
	Soil and soil conditions, including digital data, maps and image analysis
	Green transition and biomass
	Targeted regulation and measures
	Agricultural reform and public green benefits
Livestock production	Animal breeding and genetics
	Animal behaviour and welfare
	Feed and nutrition
	Nutrient cycles and animal manure
	Production systems, management and advisory service
	Animal production and measures
Food quality and consumer behaviour	Food and food quality
	Consumer behaviour and food preferences
	The importance of food and eating habits to health and sustainability



Photo: Jesper Rais

## New collaboration to strengthen cattle advisory service

A number of cattle advisors from the SAGRO advisory group have moved to AU Foulum due to an agreement between SAGRO and the Department of Animal Science, Aarhus University. About 10 SAGRO employees now have offices in the department's buildings.

The department has an extensive research education programme, and the agreement entails that several cattle advisors will begin industrial PhD programmes. Another aim is to increase cooperation in relation to research and innovation.



Photo: Jesper Rais

## Food Science moves to Agro Food Park

On behalf of Aarhus University's agricultural science, DCA has opened an office in Agro Food Park in Skejby in the centre of the Danish food cluster.

The new office will give scientists and students from food and agricultural science the opportunity to work from Agro Food Park for shorter or longer periods. Hopefully, this will encourage increased cooperation between science and industry.

At present, Agro Food Park houses about 70 different agricultural and food companies ranging from small one-man businesses to major companies such as SEGES and the Danish Technological Institute. In addition, Arla Foods recently opened a new development department in the area. The expectation is that there will be about 3000 jobs in Agro Food Park in 2020, many of whom will be AU employees. This is a result of the long-term AU strategy to gather food science research at Agro Food Park.

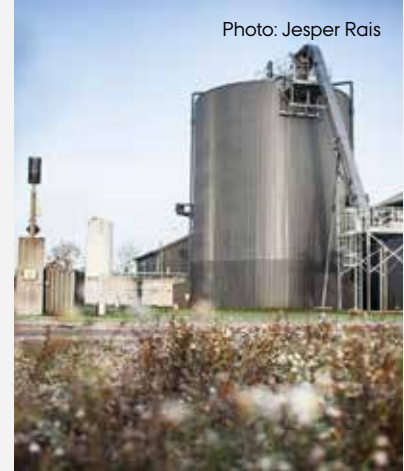


Photo: Jesper Rais

## New research to provide Apple with renewable energy – when there is no wind

On Friday September 30, 2016, Apple presented the drawings of its new data centre located in Foulum near Viborg, right next to Aarhus University. The purpose of the data centre is to process and store data – and this requires a considerable amount of energy.

In the Danish popular science magazine *Ingeniøren* (The Engineer), it was previously estimated that the data centre's energy consumption will correspond to the consumption of half a million Danish households. This significant energy consumption will be covered by renewable energy from sources such as wind turbines and solar cells. However, this means that the power supply will be unstable and difficult to store. Apple has therefore made an agreement with Aarhus University to supplement the data centre's energy supply with stable renewable energy in the form of biogas. In addition, the university will carry out research in storing energy from wind turbines and solar cells in order to stabilize the sustainable energy supply.

One of the collaborators will be Halldor Topsøe. The efforts will also be supported by a number of major current projects within the framework of Innovation Fund Denmark, the Danish Energy Agency and the Green Development and Demonstration Programme.



Photo: Lars Kruse

## Aarhus University's agricultural research among the world's top ten

No matter how you look at it, agricultural sciences at Aarhus University are among the elite according to the 10<sup>th</sup> National Taiwan University (NTU) Ranking. Within the subject "Agricultural Sciences" Aarhus University is number 10 on the list of 297 universities worldwide and in the field "Agriculture" Aarhus University is number 15.

Agricultural science is thus the research area in which Aarhus University ranks best compared to other universities – and its ranking has steadily progressed upwards year after year.

Other subjects in which Aarhus University ranks well globally are Environment/Ecology (no. 17) and Plant and Animal Science (no. 58).



Photo: Maria Randima Brauer Sørensen

## Cosy up to research

Everybody has the opportunity to get closer to the food and agricultural research in the Aarhus University departments in Foulum, Flakkebjerg and Aarslev.

This also applies to high school classes. Each year, hundreds of students visit the research environment at AU Foulum to get up close to animals in experimental facilities and work in laboratories. Read more about the opportunities to visit Aarhus University at [dca.au.dk/en](https://dca.au.dk/en)



# Food is inextricably linked with climate

All our foods affect the climate. By putting figures on the climate footprint of individual foods, researchers can help consumers and farmers to make better decisions.

When you bite into a steak or a carrot, you also have an impact on the environment – including the climate. On average, a steak is responsible for 14 kg CO<sub>2</sub> per kg food produced, whereas the carrot only has an impact of approximately 0.2 kg CO<sub>2</sub> per kg food produced. How does this work and how do other foods impact the climate and the environment?

Researchers from the Department of Agroecology at Aarhus University have been working on elucidating this. The results of their efforts provide us with figures to help us make better decisions – from production to consumption. Researcher Marie Trydeman Knudsen from the Department of Agroecology at Aarhus University explains how she and her colleagues calculate the environmental impact of foods by means of life cycle assessments:

- A life cycle assessment (LCA) is the calculation of a given product's general environmental impact. We estimate emissions throughout the entire chain. First, we identify the processes that the product went through, and then the input, output and emissions of each process.

## International cooperation strengthens the figures

It is a challenge to identify and map all processes and factors that affect the climate. Another challenge is to determine precisely the carbon footprint of each of these factors. Researchers from all over the world – including researchers from Aarhus University – are working on calculating the different types of emissions precisely. For this purpose, they carry out measurements, develop calculation models and share their knowledge with each other.

Once the researchers have gathered all the data, they convert the different greenhouse gas emission figures into CO<sub>2</sub> equivalents per kg produced food or per ha depending on which is most relevant. Next, the figures are applied for various purposes.

## Practical application of the calculations

The researchers work with three different approaches. One is to use LCA to estimate the climate impact in relation to an existing system that produces food or bioenergy in order to optimise and improve the system and find the parts of the process with the most significant climate impact.

Another approach is to use LCA to compare different food or bioenergy systems in order to assess the advantages and disadvantages of the production systems. Finally, LCA is an efficient tool when developing new innovative food or bioenergy systems and can be used as a guideline for developing the most sustainable and optimal system.

- Life cycle assessments are often interdisciplinary and take place across departments and together with the industry in national or international projects, and the environmental life cycle assessment represents part of the project, says Marie Trydeman Knudsen.

Food production affects the planet and its resources in a number of ways.

- In addition to the climate footprint, we calculate the impact of food production on nutrient losses to the environment, biodiversity, soil carbon changes, water consumption and ecotoxicity, says Marie Trydeman Knudsen. She emphasises that climate impact, nutrient loss, and biodiversity loss are the three major impacts to the planet.

- Within these three areas, Mankind has already changed the ecological processes so much that we have exceeded the boundaries within which Earth can maintain its equilibrium. We should not exceed these limits if we want a sustainable production, she cautions.



Life cycle assessment (LCA) calculates the impact of food, such as milk and beef, on the climate and environment. Photo: Jesper Rais



# Sustainability lies in the genes

Potted plants can be produced much more sustainably by using new precision breeding – instead of chemicals and GMO.

Would you like to buy potted plants that are beautiful, long-lasting and produced without the use of pesticides? It can be a difficult wish to grant for some potted plants but this could change. The solution lies in the genes.

Researchers from Aarhus University are collaborating with the commercial nursery Gartneriet PKM with the aim of developing potted plants that are equipped with selected genes that provide the potted plants with the desired traits using the latest precision breeding techniques.

The new breeding tools can contribute significantly to reducing the consumption of pesticides and other chemicals in the nursery business. In addition, due to a shorter production period, savings can be made on energy, water, and nutrients – all of which will benefit the environment and the nursery owner's finances.

## Blue bloom breaks ground for sustainability

Campanula, the popular potted plant from the bellflower family, has been chosen to be the trailblazer. With an annual Danish production of 25 mill. plants, Campanula is an important potted plant in Denmark. The total European production is 35 mill. plants per year, of which Gartneriet PKM produces almost half.

To ensure that the plant develops a compact shape and that the flowers do not wither, it is essential to contain the ethylene hormone. Ethylene is a type of aging hormone that ripens plants and fruit. To counter the effect of ethylene on potted plants, the plants are treated with Argylene, which contains silver. Argylene has environmental issues and it is therefore necessary to find a new and more sustainable solution.

Some plants are more sensitive than others to ethylene, but the nursery Gartneriet PKM has developed a Campanula that is insensitive to ethylene. This particular trait is due to a mutation to which Gartneriet PKM has exclusive rights.

## On the trail of beneficial genes

One of the project's tasks is to breed for this particular gene in "regular" Campanula. Other genes with an effect on ethylene sensitivity will also be included in the studies.

Another challenge in the production of potted plants such as Campanula is to encourage them to have a compact, bushy growth instead of becoming long and lanky. The plant hormone gibberellin causes plants to elongate but there are differences as to how sensitive plants are to this growth hormone and thus how great the need is for treatment with growth inhibitors.

The scientists will work with the genes that affect plant sensitivity to gibberellin in the same way as with the genes for sensitivity to ethylene. The aim is to develop a Campanula that is less sensitive to both aging and growth hormones and that can pass these traits on to following generations of Campanula.

- Precision-bred plants may be used in contexts where GMO is undesired, which will have great production and economic value for Danish plant breeders, says project partner Henrik Brinch-Pedersen, Associate Professor at the Department of Molecular Biology and Genetics at Aarhus University.

The four-year project has been granted 3.1 mill. DKK from the Ministry of Environment and Food of Denmark's Green Development and Demonstration Programme (GUDP).



With an annual Danish production of 25 mill. plants, Campanula is an important potted plant in Denmark. Photo: Colourbox

# Agriculture and climate affect each other

The agricultural sector contributes approx. 20 percent of the total Danish greenhouse gas emissions – and is itself impacted by climate change.

Climate change is no longer a speck on the distant horizon – it has arrived and is making itself felt. The agricultural sector affects – and is affected by – climate change. Researchers from Aarhus University are elucidating these interactions in order to prepare food production for the future. An improved understanding of the climate footprint can help the agricultural sector change its production methods and reduce greenhouse gas emissions.

An understanding of how climate changes affect soil, plants and animals can help agriculture to be prepared for changing and more extreme climate conditions.

## **Agricultural contribution to climate changes**

The agricultural contribution to climate changes stems from greenhouse gas emissions from various sources. The major contributions are from methane and nitrous oxide, which have greenhouse effects that are 25 and 298 times stronger, respectively, than carbon dioxide (CO<sub>2</sub>).

In order to ease comparison between the various greenhouse gases, their contributions to the greenhouse effect are converted to the amount of CO<sub>2</sub> which would produce the same greenhouse effect over a period of 100 years. This is known as the CO<sub>2</sub> equivalent.

According to Professor Jørgen E. Olesen from the Department of Agroecology at Aarhus University, the total Danish greenhouse gas emissions from agriculture constitute approximately 9.6 million tons CO<sub>2</sub> equivalents per year and account for about 20 percent of total Danish emissions.

– Greenhouse gasses come from sources such as ruminant digestion and slurry, conversion of manure and plant components in farmland, nitrous oxide emissions from ammonia loss and nitrogen leaching from farmland as well as energy consumption, he explains.

To this should be added emissions and leaching from pastures and crop rotations to the amount of approximately three million tons of CO<sub>2</sub> equivalents per year, which are

included in separate carbon balance accounts. These emissions mainly come from drainage and peat soil cultivation.

Agricultural emissions have decreased by more than 20 percent since 1990. However, the total Danish emissions decreased correspondingly, which means that the agricultural share is almost unchanged.

## **Water, heat and unpredictability affect agriculture**

The climate also affects agriculture. This appears from a new report on Europe's future climate and its consequences, published by the EU's European Environmental Agency (EEA) in January 2017. Jørgen E. Olesen has contributed the agricultural chapter in the report.

Future Danish climate will be characterized by more frequent incidents of torrential rain and other extreme weather conditions, increased water levels, increasing flooding risks along watercourses and in coastal areas as well as increased incidents of various climatic risk factors. These conditions will affect agricultural production.

– Higher temperatures will reduce crop yields in significant parts of Europe, but – to some extent – this will be counteracted by an increased atmospheric CO<sub>2</sub> content, which will stimulate photosynthesis. However, warmer and more extreme climate conditions also require crops to be more resistant to new diseases, pests and weeds, which will have improved conditions in many cases. However, the major threat is that we will have both increased periods of drought and more flooding incidents, says Jørgen E. Olesen.

Warmer and more extreme climate conditions require crops to be more resistant to new diseases, pests and weeds, which will have improved conditions in many cases. Photo: Søren Kjeldgaard



# Preparing cropping systems for climate changes

Climate models can be improved with more knowledge on how crops respond to climate-related stress and the atmospheric concentration of CO<sub>2</sub>.

Climate change will affect our crops. Farmers and plant breeders need to know precisely how crop plants will react to the new climate so they can prepare by breeding and growing suitable crops.

This means that computational models are needed that can predict which varieties and other crop management factors will be the best under the given circumstances. In previous research from Aarhus University models regarding regulation of plant stomata – the organs that plants use for gas exchange – exposed uncertainties at temperatures higher than 28 degrees, particularly in connection with increased levels of atmospheric CO<sub>2</sub>.

The EU project Modcarbostress, in which researchers from the Department of Food Science at Aarhus University are participating, will create new and more detailed knowledge about how crops respond to the combination of increasing CO<sub>2</sub> concentration, drought, heat and weather instability. The new knowledge can be used to improve future crop models.

The current models have uncertainties in a number of areas – especially when it comes to the interaction between drought, high temperatures and increasing levels of atmospheric CO<sub>2</sub>. These conditions often occur together and are expected to become more frequent in many areas of the world. The models lack accurate data on the combination of stress factors and this is the problem that Modcarbostress will help to solve.

The researchers from the Department of Food Science base their efforts on systematic analysis of the effect of CO<sub>2</sub> and temperature/drought on the response of photosynthesis in wheat.

- The aim is to improve our knowledge of plant physiological responses when crops are exposed to stress and high levels of atmospheric CO<sub>2</sub>. The next challenge will be to see what this means when plants are exposed to consecutive periods of stress – short and long-term, says Professor Carl-Otto Ottosen from the Department of Food Science at

Aarhus University. He has at his disposal advanced greenhouses, climate chambers and photosynthesis facilities as well as extensive experience in the control and measurement of responses to CO<sub>2</sub>.

Climate models can be improved with more knowledge on how crops respond to climate-related stress and the atmospheric concentration of CO<sub>2</sub>.

- We have demonstrated that wheat becomes less sensitive when exposed to slightly higher temperatures, particularly if the heat stress occurs prior to flowering, but if wheat is exposed to stress in the earing period there is a significant risk that the plant will not make it. This latter fact indicates that water stress is of more significance than heat stress, he says.

The three-year project is funded by the ERA-NET Plus on Climate Smart Agriculture, FACCE JPI, via the national funds of the individual member countries. The project is led by the research institute INRA in France with partners from Denmark, including Aarhus University and University of Copenhagen, the Netherlands, Germany, France and Britain.



The researchers from the Department of Food Science will base their efforts on systematic analysis of the effect of CO<sub>2</sub> on the response of photosynthesis in wheat. Photo: Colourbox

# Danish agriculture can reduce greenhouse gases

With targeted efforts, the Danish agricultural sector can meet the EU requirements regarding the reduction of climate gasses while maintaining food production. However, more research is necessary to reduce costs.

EU requirements demand that the Danish non-quota sectors – i.e. agriculture, transport, buildings and waste – reduce their greenhouse gas emissions by 39 percent before 2030 compared to 2005 levels.

The Danish efforts should focus on reducing emissions, in particular agricultural emissions of nitrous oxide and methane. Emissions concerning the production of imported fertilisers or feed are not included. The EU agreement leaves very limited opportunities for including the effects of increased soil carbon stocks. Therefore, the question remains whether it will be possible for the Danish agricultural sector to reduce direct emissions of methane and nitrous oxide without affecting production size.

Climate and agriculture expert Professor Jørgen E. Olesen of the Department of Agroecology, Aarhus University, states that this is not an impossible task. He is head of the team of researchers providing research-based policy support to the Ministry of Environment and Food of Denmark regarding the relations between food production, climate and greenhouse gases.

- One of the possibilities for reducing atmospheric CO<sub>2</sub> is to increase soil carbon stocks, but according to EU climate agreements, carbon stocks may only contribute four percent of the reduction of the Danish commitment by 2030. Another possibility is to purchase additional CO<sub>2</sub> quotas, but this approach also has an upper limit; the purchase of quotas may only contribute a two percent reduction in greenhouse gas emissions. This means that most of the reduction needs to be found by reducing methane and nitrous oxide emissions, says Jørgen E. Olesen.

## Wanted: Magic powder

With regard to methane emissions, the focus needs to be on livestock and manure stores. Methane emissions from manure stores can be reduced by e.g. slurry acidification or by using slurry for biogas production.

- In order to reduce methane emissions from our livestock we need some kind of magic powder, says Jørgen E. Olesen with a twinkle in his eye. Examples of this could be the addition of kelp, oregano or nitrate to cattle feed, since this would reduce enteric methane emissions. New patented products will soon be introduced but we do not know the prices of these yet. Researchers from the Department of Animal Science at Aarhus University currently carry out intensive research within this area.

Nitrous oxide from cultivated fields is a major contributor to Danish greenhouse gas emissions.

- We also need magic powder in this area. In this case we are focusing on nitrification inhibitors to retain nitrogen in the root zone, says Jørgen E. Olesen. Researchers from the Department of Agroecology carry out research within this particular area but further research funding is necessary to continue. All things considered, we need more research in a number of areas in order for agriculture to be able to reduce emissions.

- We need much more research to identify, develop and implement the appropriate magic powders. We also need research on national estimates for nitrous oxide emissions from various types of fertilisers and different soil types, says Jørgen E. Olesen, and continues:

- We need to research and develop new cultivation systems that can simultaneously provide high-yielding crops and a greater amount of biomass for storage in the soil. This would also benefit the aquatic environment.

Another initiative that can help reduce greenhouse gas emissions – although it requires further knowledge – is the development of new harvest methods, such as early harvest that enables improved establishment of cover crops and increased carbon stocks resulting in increased nitrogen utilisation.

## Practical application is important

Once the initiatives and mitigations have been identified and developed it is important to motivate the farmers to use them. The solutions should be efficient in relation to greenhouse gas emissions, practically applicable, and ensure that the agricultural sector can maintain its high productivity – without being too expensive.

One of the problems in achieving the 39 percent reduction in non-quota sectors is the fact that agricultural biogas is used for energy consumption (electricity and heat) in the quota-bound energy sector, where it helps to achieve the targets of the energy sector and is not credited to the non-quota sectors. A partial solution to this could be to use the biogas to substitute diesel in the heavy transport sector. Thereby renewable energy produced in the non-quota sector contributes to reducing other emissions in that sector.

- Another problem is that the 39 percent reduction is a specific reduction requirement for Denmark. When looking at the total European emission accounts, the reduction in agricultural climate gas emissions may be achieved at much lower prices if the initiatives are carried out in countries where the climate footprint per produced unit is higher. Denmark should therefore continue working for a common European regulation of agricultural emissions, says Jørgen E. Olesen.



# Oregano may reduce methane in cow burps

Cow burps constitute a climate problem, as the animals produce methane as a natural part of their digestive process. Researchers from Aarhus University have examined whether this problem may be reduced by adding oregano to cattle feed. They aim to reduce methane emissions by 15-25 percent.

In conventional dairy farming it is possible to reduce the production of methane by adding e.g. fat or nitrate to the feed or by increasing the starch content and improving feed quality. For organic dairy farmers, these remedies are either not permitted or are already being used. Here oregano may be a solution.

The researchers are currently testing the effect of supplementing feed with different amounts of oregano on rumen and intestinal fistulated dairy cows in special methane chambers at AU Foulum. The oregano-containing feed will thereafter be tested on a number of commercial organic dairy farms producing milk for the organic dairy Naturmælk. The researchers will also investigate how best to grow organic oregano and whether to process the plant either as hay or silage.

- To succeed with the oregano project in practice, it is essential that we develop a product that has both a high yield and a high concentration of essential oils. We also need to develop an organic farming concept and breed


new varieties with higher concentrations of the oils, says the project leader Senior Researcher Kai Grevsen from the Department of Food Science. He collaborates closely with his colleague Senior Researcher Peter Lund from the Department of Animal Science.

Previous studies indicate that oregano can improve the milk's fatty acid composition. The project participants will therefore research this aspect as well as the milk's flavour and composition. The hope is also that it will be possible to launch a number of new products that can be sold on the basis of their climate footprint, thus targeting environmentally conscious consumers.

The project is relevant to both organic and conventional milk farmers. Should the results be positive, they can be implemented on all cattle farms, conventional and organic, so there is a really large potential, says Kai Grevsen.

## About the project

The four-year MET-ANO project is financially supported by GUDP (Green Development and Demonstration Programme under the Ministry of Environment and Food of Denmark) and by the cattle and milk levy funds. Project partners are the departments of Food Science and Animal Science at Aarhus University, Organic Denmark, organic dairy company 'Naturmælk Amba', breeder 'Sunny Aps' and a number of dairy farmers.



Together with colleagues, Senior Researcher Kai Grevsen has tested the effect of supplementing feed with oregano on rumen and intestinal fistulated dairy cows in special methane chambers at AU Foulum.

# The pigs are loose at AU Foulum





In September 2016, a group of organic pigs were let loose in the fields at AU Foulum. The sows and piglets are part of the EFFORT project that aims to reduce feed consumption and supplementary protein in organic pig production without reducing productivity.

Today, organic feed is based on recommendations for housed pigs. This

means that organic pigs are overfed with nutrients, which is harmful to both production economics and the environment. Researchers will therefore examine how much energy the pigs ingest in the form of grass or roughage as this contribution is unknown and not included in optimisations.



# Livestock should be **robust, efficient and eco-friendly**

Researchers from Aarhus University are participating in an ambitious EU project on pig and poultry health, productivity and sustainability that includes a broad range of aspects.

Genetics, feed, feeding and management – these are some of the aspects of an extensive EU project aiming to improve efficiency and sustainability in pig and poultry production.

Researchers from the Department of Animal Science, Aarhus University, are participating in the five-year project Feed-a-Gene which has a budget of 10 million Euros and is financed by the EU Horizon 2020 framework programme. The project is coordinated by the French research institution INRA, and has 23 public and private partners from Europe and China.

The Feed-a-gene project aims to improve monogastric livestock production systems (pigs, poultry and rabbits) in order to increase overall efficiency and reduce the environmental impact. The project will develop new and alternative protein sources and feeding technologies, identify and select animals that are more adaptable to changes in conditions, and develop feeding techniques to optimise the potential in both the feed and the animals.

Professor Knud Erik Bach Knudsen from the Department of Animal Science, Aarhus University, is in charge of part of the project; i.e. the development of new types of high-quality protein based on European protein sources such as e.g. soybeans, rapeseed and green biomasses. The work package further includes the development of analytical methods for real-time characterisation of chemical and nutritional traits.



# Leadership visibility is essential to animal welfare

A leadership that sets a clear course is crucial with regard to how employees on animal farms act with the animals. A common understanding among the employees is also important.

Communication between employees and management on livestock farms is essential when it comes to animal welfare. Aarhus University researchers demonstrated this in a study carried out for the Danish Veterinary and Food Administration.

In the study, researchers from the Department of Animal Science asked a number of key persons from the agricultural sector which specific themes they considered relevant in relation to employees and agriculture. Among the persons interviewed were veterinarians and advisors.

- We notice that the importance of management as to how employees act around the animals is an important issue, where the words "signal or signal effect" recur most often among the respondents, says Postdoc Inger Anneberg, Department of Animal Science. She carried out the study with her colleague, Professor Jan Tind Sørensen, Department of Animal Science.

Inger Anneberg further explains that the increasing number of extensive farms with many animals – where the farmer is not necessarily present in the day-to-day running – makes it particularly important how and who makes the agreements with the employees, how the employees are

trained and specifically how knowledge is shared among the employees.

A general improvement of the professional level may also be essential in relation to animal welfare. For example, there is a need for courses for unskilled foreign employees. Such courses are only offered in certain local areas via advisors and veterinarians.

- Poor animal welfare is not only a question of lacking actual knowledge; it is also difficult to change behavior. This goes for both Danish and foreign employees, says Inger Anneberg who adds that constant discussions about which knowledge is the right knowledge can be a problem.

- New theoretical knowledge risks being dismissed off-hand without even being tried, or because new production systems do not allow them to be tested.

The results have been published in the DCA report "Medarbejdere i dansk husdyrbrug: Hvem er de, og hvad er deres rolle i sikring af god dyrevelfærd" (Employees in Danish livestock farming: who are they and what is their role in ensuring improved animal welfare). It is available for download at the DCA website (in Danish).

## Animal welfare classes

For young future farmers it is important that farm animals thrive so they can perform as well as possible. On the other hand, consumers emphasise the importance of giving animals the opportunity to live according to their natural behavior.

It is very important that agricultural colleges have courses in animal welfare and ethics in order for future farmers to gain an understanding and awareness of consumer perceptions and demands. This is one of the conclusions from a study on the role of agricultural colleges in relation to the students' view on animal welfare, carried out by researchers from the Department of Animal Science at Aarhus University.

The project focused on the importance of agricultural college education in relation to future farmers' perceptions of animal welfare and thus future welfare-related practices in agriculture. The researchers examined how the students perceive animal welfare, how their perceptions change as a consequence of agricultural college education, and how perceptions of animal welfare are presented to students at agricultural colleges.

The results have been published in the report from DCA "Kommunikation om dyrevelfærd" (Communication on animal welfare), available at the DCA website (in Danish).

# Systemised welfare

Researchers from Aarhus University have contributed to the development of an objective and consistent assessment protocol for animal welfare on fur animal farms. The concept will be applied on European mink farms in 2017.

Are you given enough to eat and drink? How about housing? Are you healthy? Are you given appropriate opportunities to display your natural behavior and how do you behave? A group of observers will ask mink on Danish and European mink farms these questions with a view to examining the animals' welfare.

Mink welfare assessments have recently been systemised and standardised by means of the European concept WelFur, developed by researchers from the Department of Animal Science at Aarhus University together with researchers from five other countries.

At the end of 2016, researchers from the Department of Animal Science trained a group of mink assessors in the registration system, meaning that WelFur was applicable right from the beginning of 2017. Basically, the assessors will examine if mink are provided with good feeding and housing, and if they have good health and appropriate behavior.

- The assessment includes 12 welfare criteria such as ease of movement, good human-animal relationship, absence of disease and absence of prolonged hunger. Evaluation of these criteria builds on 22 indicators, e.g. if mink are too thin, if they have wounds or injuries, or if they display abnormal behavior, explains Senior Researcher Steen H. Møller, Department of Animal Science.

Wherever possible, indicators are based on animal behavior or health, but otherwise registrations of housing or management routines are used. All indicators are chosen according to how well they reflect mink welfare, and how reliable and feasible they are.

## Taking seasonal variation into account

The life cycle of mink varies significantly from season to season. Therefore, WelFur assessments include registrations from three periods in a production year: Winter period with only adult mink on the farm (December-February), mating, gestation and lactation period (March-July) and growth period from weaning pelting (July-November).

The indicators are converted into figures in order to classify the farm within one of four welfare categories: best, good, acceptable and unacceptable. These categories are not based on average scores for each principle.

- This means that a high score for one principle will only to a lesser extent compensate for a low score for another principles. For instance, excellent housing conditions cannot make up for poor feeding, says Steen H. Møller.

In 2015-2016, WelFur was tested on 27 mink farms in 10 European countries in order to test the assessment protocol under different climatic conditions and in countries with different mink production traditions. Based on experience from the various tests as well as knowledge produced in other projects at Aarhus University, the protocol was subsequently optimised.

## Introduced to European farms

The idea is that the individual fur breeder can use the assessment to focus on the production areas that should be improved to optimise animal welfare, and the farmer will be given access to the details of the welfare assessment. For this purpose, researchers from the French research institution INRA have developed a tablet solution for direct registration, allowing the farmer to receive a copy of the results immediately following the assessment.

This ensures complete transparency as to the basis of the assessment. Once the final results for the farm in question are available, the individual farmer can consider which production areas should be in focus and also – in cooperation with his advisor – establish goals and plan efforts in order to achieve the goals.

In the spring of 2017, national advisors from all European countries with mink production were instructed in the interpretation of assessment results. This will help improve the conditions that WelFur considers poor for animal welfare. Researchers from the Department of Animal Science are in charge of the instruction. From 2017, WelFur assessors will visit fur breeders in Europe in order to assess welfare and allocate certification. According to plan, all 4,000 fur farms in Europe will be certified by 2020. Copenhagen Fur and Saga Furs will thereafter only sell mink and fox pelts that are WelFur certified.

## About the project

In 2009, the European Fur Breeders' Association initiated the "WelFur" project with the purpose of developing a welfare assessment protocol for mink and fox farms, following the standards developed within the framework of the EU Welfare Quality® project.



Together with Danish and foreign colleagues, Senior Researchers Steen H. Møller has developed a new certification system that can be used to evaluate animal welfare on mink farms. Photo: Maria Randima Brauer Sørensen



# Researchers focus on erysipelas

Erysipelas is an increasing problem for pigs and poultry in welfare friendly production systems, so researchers from Aarhus University will help create more knowledge about this infectious disease.

Erysipelas is a severe infectious disease caused by the bacteria *Erysipelothrix rhusiopathiae*. Although a well-known disease, vital basic knowledge, particularly on the infection in poultry, is lacking. The European EryPoP project aims to create more knowledge in the area. Researchers from the Department of Animal Science, Aarhus University, and their colleagues from Sweden and Italy are partners in the project.

- We will have a close look at the disease and examine infection dynamics and immunity development in poultry and pigs. This can contribute to the preparation of guidelines for the prevention of future outbreaks, says Project Researcher Tina Sørensen Dalgaard, Department of Animal Science, Aarhus University.

Erysipelas is a well-known acute disease in pigs and a suspected cause of arthritis and considerable economic losses, especially on organic pig farms. Following the change in housing for laying hens in Europe, erysipelas has become a more frequent disease in poultry flocks, including indoor aviaries and free-range and organic production. The disease results in high-mortality outbreaks, and constitutes an occupational hazard for humans.

Within the framework of the EryPoP project, researchers will define transmission routes of erysipelas, identify risk factors for outbreaks, define the role of wild boars as potential vectors and sources of infection, develop an analysis method to detect antibodies in poultry, and study the pathogenesis and immune responses to erysipelas in poultry.

The researchers will collect samples and data from poultry, pigs and wild boars in Sweden and Italy and develop a model for experimental infections in chickens in order to examine immunity.

- These studies will provide information that will be vital in the development of diagnostic methods and improvement of future prophylactic measures such as vaccines, says Tina Sørensen Dalgaard. The EryPoP project is funded by the Animal Health and Welfare ERA-Net (ANIHWA).

PhD student Mohammad Naghizadeh, Project Researcher Tina Sørensen Dalgaard and trainee Sandra Shih are working on creating more knowledge on erysipelas in poultry.



Photo: Maria Randima Brauer Sørensen



# Plant cocktail may be an alternative to **antibiotics, zinc and copper** for pigs

Mixtures of plants with antibacterial effects may help prevent and treat diarrhoea in piglets.

A mixture of plants such as ramsons, horseradish and lingonberries may be a significant element in the future treatment and prevention of diarrhoea in piglets in organic pig herds. A group of researchers from Aarhus University will examine this within the framework of a project called MAFFRA. The project has been granted two million DKK from the Green Development and Demonstration Programme (GUDP).

The researchers will investigate the possibility of developing new multi-component, plant-based feed additives against gastro-intestinal problems in pigs. According to the project leader, Senior Researcher Martin Jensen, Department of Food Science, Aarhus University, the chances for a successful outcome are possible.

- In previous research projects we have identified a number of plants with antibacterial effects against pathogenic bacteria, and we will build on this knowledge, he says. Ramsons, horseradish, lingonberries, redcurrants, summer savory and sage are all very promising plants. They are able to reduce the growth of pathogenic bacteria like *E. coli*, *Salmonella*, and *Listeria*. In a previous EU project, the project partners demonstrated that a number of antibacterial plants can inhibit the growth of bacteria such as *Campylobacter*. The promising plants are all included in the present project.

- We will test the plant species in different mixtures and concentrations and hope to find three different mixtures to work on further, says Martin Jensen.

By mixing selected plant species with differing antibacterial mechanisms, the researchers expect to achieve an antibacterial cocktail effect that will make it more difficult for the bacteria to develop resistance.

- The antibacterial effect is the total sum of all the properties that makes it possible for us to apply a reduced concentration of the individual plant species, thus avoiding too strong a taste. Neither humans nor pigs are enthusiastic about the strong taste of high concentrations of ramsons or horseradish, Martin Jensen explains.

The selected mixtures will be tested in the laboratory in a pig stomach-gut model that mimics the environment in

the gut in order to examine the ability of the mixtures to inhibit the pathogenic intestinal bacteria. The aim is not necessarily to kill the bacteria, but to achieve a healthy balance in the gut flora. If the results are promising, the researchers will try to achieve funding for a major follow-up project that will include feeding experiments with pigs.

## About the project

MAFFRA is a part of the Organic RDD 2.2 programme, coordinated by the International Centre for Research in Organic Food Systems (ICROFS). The project is financed by the Green Development and Demonstration Programme (GUDP).



Ramsons is one of the promising plants with an antibacterial effect. Photo: Martin Jensen

# Application of animal manure affects the abundance of antibiotic resistant genes in soil

The use of animal manure increases the soil content of antibiotic resistant genes. However, this is not an irreversible situation.

Aarhus University has one of the world's longest-running field experiments – but what does this have to do with the appearance of antibiotic resistance? The answer is that this field experiment forms the platform for illuminating the interaction between the use of animal manure and the appearance of genes for antibiotic resistance in soil.

Investigations show that when a certain type of antibiotic is phased in, the abundance of resistant genes in the soil increases. When the antibiotic is phased out again, the abundance of resistant genes drops – and this happens relatively quickly.

The analyses were carried out by researchers from Newcastle University, Great Britain, and Strathclyde University, Scotland, using soil samples regularly collected since 1923 in the now 122-year-old fertiliser experiment at Askov Experimental Station at the Department of Agroecology, Aarhus University. The results are described in an article in the prestigious scientific journal *Nature Scientific Reports*.

- We found low levels of resistant genes in samples collected before 1960, both in manured soil and in soil treated with inorganic fertiliser. Manured soil samples collected in the 1970s demonstrated a significant increase in the abundance of resistant genes against the types of antibiotics used in the different periods. Once a certain antibiotic was phased out, the abundance of resistant genes was swiftly reduced, explains Professor Bent Tolstrup Christensen from Department of Agroecology. He is project leader of the Askov long-term experiments and co-author of the article.

He further adds: - In the mid-1990s, the use of antibiotics as a growth promoter fell. This led to a corresponding rapid fall in the soil abundance of antibiotic resistant genes.

Throughout the period, the soil receiving inorganic fertiliser had very low levels of the resistant genes. These levels corresponded to the prevalence of resistant genes in soil collected in 1923 and 1938 before the use of antibiotics. The timing of the first appearances of the resistant genes in the health service corresponds to the timing of their highest abundance in soil.

- Although the development in the abundance of resistant genes in soil mirrors what you see in the health service, research has not yet made a connection between the two. The results show that the use of antibiotics will result in resistant genes in all sectors but they also show that the phasing out of antibiotics can swiftly lead to a reduction in the incidence of resistance – and that is good news, says Bent Tolstrup Christensen.

The story does not end here. Analyses of the historical samples also showed another development that is more worrying. Since 1990 there has been a growing level of integrons in manured soil. Integrons promote the exchange of genetic material between bacteria and can therefore accelerate the development of new resistance. Whether the incidence of integrons is connected with an increased amount of heavy metals is still unknown.

# The many faces of soil

A new research project at Aarhus University will delve into the secrets behind soil properties in relation to the soil's water content. This knowledge is relevant for agricultural and engineering applications.

Here is a puzzle for you. Imagine you have a dry soil and you soak it up with water until a given relative humidity, for example 50 percent. At this given humidity, you carefully measure the amount of water contained in the soil. Doing this for different relative humidity levels produces the so-called soil water vapour sorption isotherm.

You then dry the same soil from a previously water-saturated state until the same relative humidity of 50 percent and carefully measure the amount of water from the soil. You would expect the amount of water obtained from the wetted soil to be the same as that of the dried soil, right? Wrong!

Scientists have found that there is a difference in soils' water sorption ability – the so-called water vapour sorption – depending on whether the soil is absorbing water or releasing it. The mechanism behind this is a puzzle that a new project at Aarhus University intends to shed more light on.

Researcher Emmanuel Arthur from the Department of Agroecology is the leader of the project and has received a grant of DKK 4.5 mill. from Villum Fonden to carry out the four-year investigation.

## Soil with a past

The ability of the soil to hold water depends on its previous history, which is whether it is coming from a dry condition and absorbing water or coming from a wet condition and releasing water. This phenomenon is called hysteresis.

If researchers can get a handle on the mechanisms determining sorption hysteresis they can develop a novel framework that can integrate the concept in water vapour transport models several other soil processes. Furthermore, the projects aims to estimate soil properties that are otherwise difficult to measure, such as surface and engineering properties from a simple measure of soil water content considering hysteresis.

The researchers will also focus on soil surface properties like water repellency, which are essential for agronomic processes such as plant water utilisation, preferential leaching of pesticides and nutrients.

## Soil takes many forms

The researchers will also investigate other properties that are crucial for characterising soil for engineering applications. Some soils, such as clay, change in size depending on their water content. When clay is wet it swells and when it dries it shrinks. The shrink-swell potential describes this property. The shrink-swell potential is important to identify when erecting buildings or other forms of construction on soil. Soils that shrink markedly when dry can also affect crops by damaging their roots.

Another property is the Atterberg limits which help describe what happens when soil changes its form depending on its water content. Once again, think of clay. Very wet clay can be almost liquid, when partially wet it becomes plastic, and when completely dry it is hard enough to use as bricks for building but very difficult to plough.

The project is based on a wide range of samples that will include pure clay, clayey soil, sandy soil, young Greenland soil, expansive and low activity soil, and organic soil.

- We expect that the results will facilitate rapid estimation of the selected properties from easy-to-measure data and assist in policy-making and research that requires knowledge of soil surface properties on regional or national scales, says Researcher Emmanuel Arthur.



# Machine design and crop choice can reduce soil compaction

Heavy agricultural machinery used to cultivate the soil, apply animal manure and harvest crops contributes to degradation of farmland. Innovation in relation to technology and crops can help remedy this serious problem.

Danish soil is under pressure – literally speaking. The heavy agricultural machinery that is supposed to provide a solid basis for a productive harvest actually contributes to the exact opposite. The heavy machines compact the soil leading to long-term and even irreversible damage.

Within the framework of a four-year project, researchers from Aarhus University, together with partners from the University of Copenhagen, Green Agro & Transport, Jysk Landbrugsrådgivning, SEGES, DLF and Michelin, will collaborate to develop methods to prevent and remedy the damages caused by soil compaction.

It is commonly known that both tire pressure and wheel load contribute significantly to soil compaction. Innovative measures are needed to ensure improved distribution of the weight impact on the soil. The project partners aim to develop and test a new design for vehicles transporting straw and grain crops.

Plant roots from the main crop or catch crops can improve the quality of the compacted soil by establishing a network of tiny pores in the soil and increasing the formation of an improved soil structure. Increased earthworm activity may be expected when growing catch crops.

However, the question is to which extent the plant roots are actually able to improve soil structure in soil with serious compaction damages. Therefore, part of the project will be to examine this in field trials and in controlled conditions.

The project focuses strongly on the application of solutions to reduce compaction problems. This will be accomplished by developing the decision support system Terranimo® in close cooperation with farmers, advisors and researchers. In addition, solutions for reducing compaction problems will be demonstrated in open field events.

## About the project

The COMMIT project has received a grant of 11.7m DKK from the Green Development and Demonstration Programme (GUDP).



It is commonly known that both tire pressure and wheel load contribute significantly to soil compaction. Innovative measures are needed to ensure improved distribution of the weight impact on the soil. Photo: Janne Hansen

# Fungal disease resistance on **the wrong course**

Pesticide resistance is on the rise, which can be a problem when, for example, wheat becomes infected with Septoria disease.

In Denmark, we only have a limited number of fungicides to control the fungal disease Septoria in wheat. Every year this disease causes significant yield losses. The limited types of fungicides means that disease control to a major extent depends on the application of triazole fungicides and a few relatively weak SDHI-fungicides. The Septoria fungi is after many years of intensive herbicide use beginning to develop resistance. Via field experiments, researchers from the Department of Agroecology at Aarhus University keep a close eye on resistance development and perform research in different control strategies.

- We have witnessed a change in resistance levels from 2015 to 2016. We have seen this development in other countries and it is rather disturbing as triazoles remain the core of our control strategies and as only a few alternative fungicides exist for controlling Septoria. Loss of triazole effect reduces the possibilities of avoiding yield loss, says Senior Researcher Lise Nistrup Jørgensen from the Department of Agroecology.

- Data from 2016 show that the number of mutations that influence the reduced effect has increased since 2009, and laboratory tests further showed that isolate sensitivity is reduced. The increased incidence of certain mutations indicate that Danish conditions are increasingly similar to those known from British and Irish studies that demonstrate a strongly reduced triazole effect in the fields.

The most important means to avoid resistance development in Septoria is to grow resistant varieties that need less applications as a starting point. Based on research results, researchers further recommend application of different types of triazoles during the growth season – either by alternating or using different mixtures as this may help keep resistance development at a minimum. In addition, it is important to reduce the number of applications and to use fungicides with different effect mechanisms.

# Integrated pest management is the solution of the future

Currently we are witnessing the impact of a more restrictive EU legislation leading to a reduction in the number of pesticides available to the farmers. This development highlights the need for integrated pest management to support a sustainable crop production.

For some years, the Danish agricultural sector has faced challenges with regard to access to efficient pesticides, and there are no signs that this will be any easier in the future. This is one of the key reasons for resorting to other measures than simply pesticides when dealing with weed, pest and disease control.

- EU is implementing stricter procedures for the approval of new pesticides, and there is no doubt that EU legislation will have an increasing influence on the access to effective pesticides in future years, says Professor Per Kudsk from the Department of Agroecology at Aarhus University. Besides fewer tools for effective control, with only few authorized pesticides available, pests, weeds and diseases are also more likely to develop resistance to these pesticides.

One solution to overcome this is integrated pest management in which pesticide use is just one of a broad range of tools.

At the European level, the Department of Agroecology is a leader within sustainable crop protection, and in 2016 the department participated on behalf of the Danish Ministry of Environment and Food in a European network (ERA-net) within this particular research area. The ERA-Net C-IPM (Coordinated Integrated Pest Management) comprised 32 institutions from 21 European countries.

In addition to mapping the current knowledge of integrated pest management in Europe, C-IPM has identified areas that lack knowledge and has coordinated calls for new European projects. C-IPM ended in 2016 and resulted in a strategic EU research agenda as well as the launch of 16 new international research projects with the participation of researchers from a number of countries.

## Controlling potato late blight

Researchers from Aarhus University participate in five of these projects. One of the projects aims to improve the control of potato late blight. In Europe, the cost of potato late blight control amounts to an average of about one billion euros a year.

The pathogen causing potato late blight is mutable, which makes control very challenging. The three-year project has

a budget of 1.2 million euros, and researchers from France, Norway, Estonia, Great Britain and Denmark will approach the problem by analysing the genotypic and phenotypic variations and evolution of the pathogen. In addition, the project will develop decision support systems.

The project builds on the monitoring activities carried out within the EuroBlight network, and complements them by providing critical, but currently unavailable phenotypic data.

- Aarhus University is very active in the EuroBlight network, which has carried out DNA analyses of approximately 2,800 pathogen isolates during the last three years. Isolates were collected in all of Europe. This provides us with an overview of the genotypes found in Europe, their frequency and prevalence, says Jens Grønbech Hansen from the Department of Agroecology. He participates in both EuroBlight and the new C-IPM project.

Denmark also participates in new C-IPM projects dealing with the application of integrated pest management used to control *Meligethes aeneus* in rapeseed, fungal diseases in grain cereals, including *Septoria*, and herbicide resistance in rye grass.



In Europe, potato late blight control amounts to an average of approximately one billion euro a year. Researchers from Aarhus University participate in a project aiming to control the crop disease. Photo: Janne Hansen



# Healthy crops with minimum pesticide use

Researchers from Aarhus University are investigating various alternative strategies to protect fruits, vegetables and ornamentals against diseases, pests and weeds in order to reduce or even drop pesticide use

Pesticide consumption in the horticultural sector in Denmark is low compared to other countries, but there is still room for improvement by using new methods that are being developed in collaboration between researchers and the horticultural industry.

On the one hand, we consumers want the fruits and vegetables that we place in our shopping cart to look good and not have any spots, mould or wormholes. On the other hand, we also like to see that the products are produced with a low input of pesticides or even none at all.

This is a difficult dilemma for Danish horticulturalists but help is on the way. A project led by Aarhus University will develop novel methods for protecting fruit, vegetables and potted plants so that pesticide use can be reduced or even avoided altogether – and thus increase profits in the Danish horticultural industry.

The four-year HORTPROTECT project is a collaboration between Aarhus University, University of Copenhagen, Gartnerirådgivningen (HortiAdvice Scandinavia), and companies that develop new technologies.

- Efficient plant protection is crucial to profitability in the horticultural industry – both the organic and conventional sectors – but it is not always so easy, says the leader of the new project Professor Per Kudsk from the Department of Agroecology at Aarhus University.

## More instruments for the tool box

In recent years many pesticides have disappeared from the market due to restrictive approval policy in the EU and Denmark. This development has contributed to a decline in production in some of the sectors of the horticultural industry, including potted plants and berry production. However, pesticides are not the only way to go – other solutions exist.

- Our goal is to develop integrated solutions that are not only interesting for conventional production but can also in some cases be put to use in organic production. One of the greatest challenges facing current organic production is the lack of efficient plant protection methods, says Per Kudsk.

To protect against weeds in vegetables, the researchers will, among other things, test and develop direct drilling and strip tillage.

With this method the seeds are sown directly in a cover crop that has previously been established. The advantage of this method is avoidance of weed germination due to no soil disturbance, cover crop competition, and a potential chemical-biological (allelopathic) effect of the cover crop on the weeds.

Another possibility is to develop various strategies and technologies for treating the crop rows and between the rows, respectively. This can be relevant if, for example, there are different times at which mechanical weeding is optimal in the rows and between the rows.

In order to prevent fungicide resistance and minimise pesticide residues another thing the researchers will investigate is to what extent it is possible to include biological protection of strawberries against mould. The researchers will also survey and optimise the effect of microbiological agents in greenhouses and outdoor vegetables as well as investigate the effect of crop rotation, catch crops and bare fallow on the occurrence of nematodes in outdoor vegetables.

## About the project

The HORTPROTECT project has been granted six million DKK from the Green Development and Demonstration Programme (GUDP) under the Ministry of Environment and Food of Denmark. It is a collaboration between Aarhus University, University of Copenhagen, Gartnerirådgivningen, and companies that develop new technologies.

In order to prevent pesticide resistance and avoid pesticide residues, the researchers will investigate whether it is possible to include biological protection of strawberries against grey mould. Photo: Colourbox

# New algorithms ensure improved harvest

Researchers from Aarhus University have entered into a collaboration with one of the world's leading manufacturers of agricultural machinery. They are now well on the way with the first version of a fleet management system that can optimise a farmer's harvest.

Economies of scale and efficiency improvement are key words for the latest trends in the development of agriculture. Farmers who take care of their soil obtain a better crop yield. An optimised harvest can provide both fuel and cost savings. Farmers can now get help in planning the whole process with computer intelligence.

In recent years, researchers at Aarhus University have been working intensively on developing computerised fleet management tools for agriculture. They have now completed the first early prototype of a system that can control all the machines involved in a harvest, giving them the best possible route in relation to each other.

- Computer intelligence can lift the logistical planning involved in agriculture to a completely new level. We have developed an algorithm that can select the mathematically optimal route for each of the machines involved in harvesting. This means that farmers can save time, fuel and money in their operations, and at the same time limit the driving to certain areas of the field, says Senior Researcher Claus Aage Grøn Sørensen from the Department of Engineering.

## No more harvesting using the same patterns

For the time being, the researchers have shown positive results in computer-simulated harvesting operations. With the new algorithms, they can control the harvest in a defined area with route planning that takes into account field and vehicle dimensions

- In principle, we are doing away with traditional harvest methods in the fields, where there is no overall control of harvesting machines and transport vehicles. Instead, we are letting the computer work out how the machines should move around in relation to each other, taking into account the status of the machines and the field. It means the driving patterns become more complex, says Claus Aage Grøn Sørensen.

For major agricultural regions such as the USA and Eastern Europe, the technology can have a significant impact on the efficiency of the harvest. It is not uncommon for farmers in these areas to keep track of five combine harvesters and a corresponding number of transport units in one operation.

## Fewer kilometres mean increased efficiency

When the 2017 harvest begins, the researchers will try out the intelligent fleet management in Danish fields. In connection with the 2016 harvest, they used a GPS logger to record the driving behaviour of the farmers in the same fields, and this will make it possible for them to assess the efficiency improvement potential of the technology. Under certain conditions, computer simulations of other field operations have shown driving savings of up to 15 per cent.

- We hope we can reduce driving on the fields by 10 per cent in connection with harvesting. This may not sound like very much, but at an aggregate level, it would provide considerable global savings of both fuel and time as well as repeated traversal of the field, says Claus Aage Grøn Sørensen.

## About the project

The project Off-line and on-line logistics planning of harvesting processes has been granted 5 million DKK by Innovation Fund Denmark. Aarhus University and AGCO are project partners.



Using the same patterns for harvesting the fields is a thing of the past. A new algorithm enables a simple computer to control the most optimal driving pattern for both combine harvesters and transport units in the same operation. Photo: Colourbox



# Focus on environmental technologies

From air purifiers, slotted floor scrapers and slurry acidification to weed robots and LED lights in greenhouses; Danish farmers use a broad range of environmental technologies every day.

Researchers from Aarhus University frequently focus on a number of these technologies to describe their effect in relation to environmental and cost efficiency. This is part of the agreement between the university and the Ministry of Environment and Food of Denmark on the provision of research-based policy support. The Danish AgriFish Agency uses the reports when prioritising which applicants to consider for grants from the Environmental Technology Development and Demonstration Programme.

In 2016, seven different effort areas were included in the call for applications, and this is reflected in a report from DCA – Danish Centre for Food and Agriculture. The report deals with qualified technologies for the reduction of am-

monia emissions and energy consumption on cattle and pig farms as well as technologies for reducing energy, nutrient or pesticide consumption in the nursery sector.

The requirements for the included technologies are that they should result in reduced consumption of pesticides, fertilisers etc. of at least 10 percent compared to standard technologies. However, energy savings and CO<sub>2</sub> reductions should be at least 30 percent. In addition, application of the technologies must not be a statutory requirement.

The researchers from Aarhus University also prepared a scientific report and a list of technologies, which the Danish AgriFish Agency uses to prioritise applications for the purchase of technologies to increase organic production.

Both lists are available at the Danish AgriFish Agency website.

## Nitrogen, clover, camera and image analysis **come together**

New technology has found its way to clover grass fields and can help improve farmer's profitability and the environment. The three-year CloverSense project has been granted 5.5 mill DKK by the Green Development and Demonstration Programme (GUDP). The project is a collaboration between scientists from Aarhus University and the private companies Agrolntelli, I-GIS and DLF on the development of tools to support the farmer in optimising nitrogen fertilisation of his or her clover grass fields.

The project partners will customise existing technologies and use them to determine the ratio between clover and grass. In addition, the project partners will develop nitrogen application algorithms that build on the ratio between

clover and that will be used to make fertiliser maps. This will enable the farmer to improve nitrogen utilisation to the benefit of both contribution margin and the surrounding environment.

The project partners aim to develop three commercial products: a camera system to be mounted on grass mowers, a web platform, and an app for smartphones. The project partners will build on a technology that is based on results from previous research projects at Aarhus University.

The new technology is expected to provide savings in the agricultural sector amounting to 96 million DKK as well as reduce environmental load and climate impact.



# Is grass the new gold?

Green fields of grass can play an essential role in the transition to a biobased economy but doing so will require further development of current technologies and changes in agricultural practices.

Green growth and transition is key to ensuring sustainable development in a world with limited resources. How can this come to be and what will it mean – not just for Danish economy and energy production but also for the environment and nature?

According to a group of researchers from Aarhus University and the University of Copenhagen, one solution is particularly important for making Danish economy more sustainable. The solution is an increased production of green biomass.

In 2012, the researchers published the report "The +10 million tonnes study", in which they described how to increase the Danish biomass production from agricultural land and forests with up to 10 million tonnes of dry matter per year – without reducing food production.

In 2016, the researchers from Aarhus University and the University of Copenhagen published a revised version of the study, calculating the national effects on greenhouse gas emissions of the scenarios in the report.

- A conversion of 10 percent of the farmland area to more productive crops such as grass can help reduce the Danish emissions of greenhouse gasses by up to 20 percent, says Senior Researcher and one of the authors of the report Uffe

Jørgensen from the Department of Agroecology at Aarhus University.

Subsequently, green biomasses can be used to produce green energy and new feeds; another benefit is that cultivating grass improves biodiversity and soil quality and reduces nitrogen leaching to the aquatic environment.

- Developing the current agricultural production and moving towards increased resource utilisation require considerable efforts, but they are necessary. It is difficult to increase biomass production significantly within the current agricultural framework. Cereals are relatively easy to produce and process, but ordinary crops are not the most efficient when it comes to utilising sunlight or fertilisers, says Uffe Jørgensen.

## Higher yields than grain crops

Compared to grains, grass and other green crops have considerably longer growth periods and utilise sunlight and fertiliser much better. Under Danish conditions, green crops can provide higher yields than grain crops.

One of the questions that the researchers often meet is whether Danish consumers should give up bread and eat grass instead; but are not yet that far, assures Uffe Jørgensen:



We use only two percent of our current cereal production for bread and grains. Most of the grain is used for animal feed so we can easily reduce cereal production slightly and grow grass for animal feed instead, without reducing bread production, says Senior Researcher Uffe Jørgensen.

#### Centre for Circular Bioeconomy

A bioeconomy based on biological rather than fossil raw materials is a crucial part of the circular economy, and Aarhus University is in a particularly strong position through the research strengths of Science and Technology. In May 2017, the Faculty established the Centre for Circular Bioeconomy with the clear aim of ensuring synergy within interdisciplinary research in this field as well as strengthening collaboration with national and international companies and organisations working in the field of biobased economy.

Read more at [www.cbio.au.dk/en](http://www.cbio.au.dk/en)

- We will still produce cereals. However, only two percent of our current cereal production is used for bread and grains. Most of it is used for animal feed so we can easily reduce cereal production slightly and grow grass for animal feed instead without reducing bread production.

An increased Danish focus on green biomass will be noticed internationally. Researchers from Aarhus University are currently experimenting with extracting protein from grass, in the hope that it will be possible to produce Danish protein feed for animals and protein ingredients for the food industry. This will reduce the current import of soybeans. The remaining grass can be used for both feed and fuel production.

#### New thinking, knowledge and methods necessary

More research and development is needed within the agricultural sector in order to realize the full technological and environmental potential of an increased biomass production, both within the industry and at the universities. First and foremost, the methods used to produce high-value products from grass – primarily protein – should be further developed, allowing establishment of an industry that can use the grass.

The first challenge is to extract protein from green biomass in a quality and at a price that is competitive compared to

soy protein. Next, the residue should be readily convertible into high-value products.

At the same time, a range of plant production technologies and systems need to be developed before all the new product chains can be realised and implemented. For instance, we need systems to handle grass in long-term rotation in order to maintain high yields. To strengthen interdisciplinary research and ensure synergies within the area, the faculty Science and Technology at Aarhus University established the Centre for Circular Bioeconomy in May 2017. Uffe Jørgensen was appointed Head of Centre.

- Biomass is in great demand and we have many customers, as there will be a demand for more sustainable energy and food in the future. For many years, we have considered these needs as competing purposes, but we are wrong to think that there is a fixed amount of biomass to be distributed. If we act wisely, we can produce far more and, at the same time, solve a series of environmental problems that the agricultural sector faces and that may be fatal to the industry in the future, says Uffe Jørgensen.

Read more about the new Centre for Circular Bioeconomy at [www.cbio.au.dk/en](http://www.cbio.au.dk/en), where you can also download the report "10 million tonnes study".

# Organic farmers to grow and harvest the manure of the future

In the production of organic fruits and vegetables, which is growing due to an increased consumer demand, farmers use animal manure as fertiliser. At present, however, there is a shortage of organic animal manure. Danish organic farmers are therefore given a dispensation to use a small amount of conventional animal manure. However, organic farmers prefer to use organically produced manure and hope that the need for a dispensation will soon come to an end.

Therefore, a group of researchers from Aarhus University, together with the industry, has worked to develop alternative sources of fertiliser for organic farming. A completed project demonstrated that mobile green manure (plant-based fertiliser) can be an alternative to animal manure – without affecting the yield.

Green manure is a well-known method of building up soil fertility and recirculating nutrients. Traditionally, it entails that the farmer grows legumes such as red or white clover, which are incorporated into the soil. This benefits the subsequent main crop. Project manager and Senior Researcher at the Department of Food Science, Aarhus University, Jørn Nygaard Sørensen explains:

- The news is that we have demonstrated that instead of ploughing the legumes into the soil, we should harvest them and use them as a fertiliser in another field with for example cauliflower or leek.

## More harvests and improved fertiliser

The major advantage of mobile green manure is that you can harvest repeatedly and achieve different manure crop qualities. The quality depends on the carbon:nitrogen ratio. If the manure crop contains too much carbon in relation to nitrogen the nutrients will be released too slowly. On the other hand, high nitrogen contents will result in a quick release of nutrients.

- When you grow vegetables it is of major importance that the fertiliser nutrients are released quickly. Therefore, it makes good sense to harvest green manure crops at an early growth stage with a low C:N ratio. Using mobile green manure means that you can harvest repeatedly and at the same time achieve improved fertiliser, says Jørn Nygaard Sørensen. He also states that the experiments show that it

is possible to produce more than 500 kg of nitrogen per ha in one growth season.

- We also demonstrated that mobile green manure with a high nitrogen level in relation to carbon is just as efficient as animal manure.

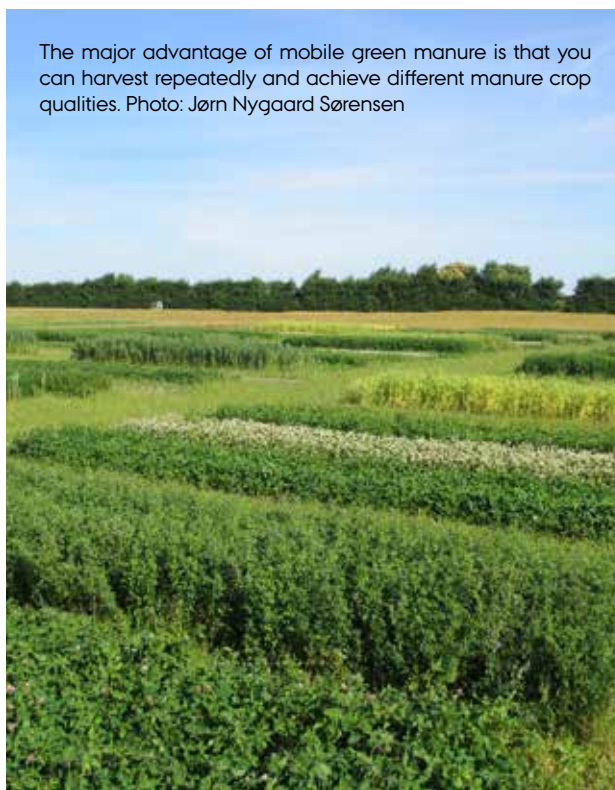
The cheapest manure is achieved by using fresh green manure. It may be necessary to save green manure for later purposes, but composting, ensiling or drying make the manure more expensive.

## About the project

The project "Maximum production of organic nitrogen using green manure" is funded by the Green Development and Demonstration Program (GUDP), the Ministry of Environment and Food of Denmark.

The project was carried out in collaboration between Aarhus University, Økologisk Landsforening (Danish Organic Farming Association), HortiAdvice Scandinavia (GartneriRådgivningen A/S), Skiftevær Økologi Aps (an organic farm) and FarmerGødning I/S (a company selling organic manure).

The major advantage of mobile green manure is that you can harvest repeatedly and achieve different manure crop qualities. Photo: Jørn Nygaard Sørensen





# Biochar – residue with major potential

Biochar is the term used for the solid residue left when biomasses such as straw and wood chips are degassed at high temperatures without oxygen and thus converted to gas and oil.

At Aarhus University's experimental facilities in Askov, researchers carried out a number of experiments to examine the effect of biochar on crop growth. There is every indication that biochar can be used to reduce the emission of greenhouse gasses as well as a tool for soil improvement. In an experiment with winter wheat, the researchers incorporated two types of biochar into the soil – one type made of straw and another type made of slurry fibre. A third treat-

ment was included, in which both types of biochar were added at the same time.

In 2016, early winter wheat growth demonstrated a significant effect of the added biochar; green crop biomass yields were considerably higher for treatments with biochar, in particular biochar from straw. During the growth season, the difference decreased relatively. At harvest time, grains and straw from plots treated with biochar demonstrated significantly higher yields compared to reference plots without biochar. Field experiments with barley and rapeseed will examine the effect of biochar on durability and reproducibility.



# Potatoes – a **sustainable alternative** to animal protein

Many food products contain animal protein from eggs or milk, but new research will potentially enable these to be substituted by high quality protein extracted from potato. Hereby we can use this tuber vegetable far better and meet the strong demand for protein.

Denmark has a large potato production and the potato starch manufacturers KMC and AKV receive on a yearly basis more than 1.2 million tonnes of potato, which are mainly used for starch production in the form of potato flour.

However, the production of potato starch leads each year to a 10,000 tonne potato protein residue, which cannot be used in food production. This is because it contains toxins and undesirable enzyme activity – one of the effects of this is that potatoes will eventually turn brown when processed. The protein by-product is therefore currently only used for animal feed.

Within the framework of the new Propotato project, Aarhus University will, in collaboration with the University of Copenhagen, KMC, AKV Langholt and DuPont Industrial Biosciences, develop new and healthy protein ingredients based on the potato protein that currently ends up in feeding troughs. With a growing global population, there will be a steadily growing demand for food. By changing our diets away from eating a lot of meat to mostly eating plant-based products, it will be possible to feed more people without encroaching on countryside that is currently not used for farming.

## Elimination of potato browning

Postdoc Jesper Malling Schmidt, Department of Food Science at Aarhus University, submitted his PhD thesis that became the forerunner of the Propotato project, and he participates in the project. He explains that certain barriers make it difficult to use potato protein for foods:

- If the potato turns brown, it is difficult to separate the brown pigment from the protein. Further, browning has a negative impact on protein digestibility and solubility. Therefore, we try different methods to destroy the enzyme that makes the potato turn brown.

The project approaches the problem from different angles: at the iNano Centre at Aarhus University, researchers add enzymes in order to avoid browning, and at the Department of Food Science researchers carry out experiments in which they add the antioxidant ascorbic acid and sulphuric acid, which both lower the pH value.

- In addition, we will carry out ultrasound experiments to see if this will eliminate the problematic enzyme, says Jesper Malling Schmidt.

So far, the results are promising:

- The so-called inhibitors ascorbic acid and sulphuric acid seem to have positive effects. However, we prefer to avoid adding acids as protein function may be reduced when the pH value is lowered this way. Therefore, we will experiment with ultrasound, he explains.

Another part of the project focuses on eliminating some of the chemical compounds known as glycoalkaloids found in potatoes.

These act as a kind of natural pest protection in plants such as potatoes and tomatoes; however, in large amounts they turn toxic and have an acrid taste. The University of Copenhagen carries out research to identify enzymes that are able to destroy the glycoalkaloids, while Aarhus University's Department of Food Science works with ultrafiltration as a means of washing out the toxins.

## Potato protein in flødebolles (chocolate covered marshmallow)

When researchers succeed in separating the protein, which areas would be suitable for substituting animal protein by potato protein? One example might be in chocolate covered marshmallows, mayonnaise or vegetarian "burgers". However, this requires stable protein that is applicable as intended, also when processed:

- Later in the project period, we will have a closer look at the most important aspect – functionality: Can you whip it to a foam to be used as filling in chocolate covered marshmallows, and is it capable of emulsifying as well as eggs when producing mayonnaise?, explains Jesper Malling Schmidt.

Generally, there are many aspects to consider: the financial aspect is an important factor in order for the two participating companies to make extensive use of the technique as some of the added enzymes are very expensive.

Still, there are no indications that consumers will refuse to eat foods in which animal protein has been replaced by plant-based protein. Another project participant, the MAPP Centre at Aarhus University, carried out a consumer study that specifically addressed the topic of cookies made by potato protein and received mainly positive responses.





### About the project

The Propotato project received funding from Innovation Fund Denmark to the amount of 14.3 million DKK, and has a total budget of 20 million DKK.

Project participants are: Aarhus University, the University of Copenhagen, KMC, AKV Langholt and DuPont Industrial Biosciences

Postdoc Jesper Malling Schmidt and his colleagues will try to develop plant-based ingredients based on the potato protein that currently ends up in feeding troughs. Photo: Maria Randima Brauer Sørensen.



# Mussels and insects are possible new **protein sources**

In recent years, insects and mussels have received considerable attention as alternative protein sources in food and feed. In addition, mealworms and mussels seem to contain substances that are beneficial to animal health.

The global demand for food of animal origin is increasing. In order to meet the demands of a growing population, there is a need for new feed protein sources to replace soybean imports that mainly come from South America.

Researchers from Aarhus University are therefore developing protein source alternatives that can be used for both animals and humans.

The overall goal of the inVALUABLE project is to establish an industrial production of insects for feed and food with an annual turnover of 200-300 million DKK and, hopefully, 200 related jobs.

The project focuses on mealworms as these are a serious alternative to other protein sources and can be fed biomass that is not readily edible by humans and animals. The insects can thus convert low-value products into valuable food and feed.

Associate Professor Jan Værum Nørgaard from the Department of Animal Science, Aarhus University, will be in charge of the efforts that deal directly with the animals. Together with his colleagues, he will assess whether mealworms can be used as human nutrition by examining how pigs digest the insects. The pigs are thus used as models for humans.

In addition, the researchers will examine how mealworms affect piglet health and growth.

- We assume that insects contain substances that are beneficial to the immune system. We hope that we can identify properties that will enable us to reduce the use of antibiotics in pig production merely by adding insects to the feed, explains Jan Værum Nørgaard.

## **Pigs are not picky**

Even though insects have been recognized as an environmentally friendly and realistic alternative to well-known feeds and foods, the demand is still at a minimum. If insect production is to be viable, the demand for insects must be great. Therefore, the researchers at Aarhus University will try to establish a basis for an increased demand.

- Among Danish consumers, the market for insects is insignificant. Luckily, pigs are not picky, so it is easier to sell insects as animal feed. However, we expect a strongly increased demand from consumers and livestock farmers when protein sources become scarce in the long term, says Jan Værum Nørgaard.

## **Mussels to provide improved water quality and sustainable protein**

Within the framework of another project, MuMiPro, researchers, in collaboration with the industry, will develop a new type of mussel farming that provides sustainable feed protein for organic livestock production while improving the marine environment in Danish coastal waters.

Associate Professor Jan Værum Nørgaard is in charge of examining the application of mussels as animal feed. The need for organic protein is expected to increase once EU requirements that feed for organic livestock must be 100 percent organic come into effect in 2018.

- We assume that mussels contain nutrients that the animals need – and from previous experiments we know that mussels constitute an excellent protein source, and that they also contain interesting fatty acids that can be beneficial to animal health, explains Jan Værum Nørgaard. In collaboration with Udviklingscenter for Husdyr på Friland and SEGES Ecology, he will carry out experiments with pigs and poultry in commercial herds in order to see whether mussel meal can be used in the same way as traditional protein sources. In addition, they will investigate whether it is possible to identify effects that are beneficial to animal health in practice.

## **Moving nutrients from water to troughs**

Apart from being an excellent protein source, mussels can purify water. There is thus huge potential for improving the aquatic environment in the nutrient-rich fjords using long-line mussel farming.

- The mussels filter the water for nutrients from which they grow, and by feeding mussels to the animals, we are able to move nitrogen and phosphorus from the aquatic environment and into feeds instead; here we also need nitrogen and phosphorus, says Jan Værum Nørgaard.

### About the projects

The inVALUABLE project has a total budget of 28 million DKK, and received a grant of 19 million DKK from Innovation Fund Denmark. Project partners include the Danish Technological Institute, Aarhus University (Department of Animal Science), the University of Copenhagen (SCIENCE), Technical University of Denmark (National Food Institute), Proti-Farm R&D, Novozymes, Hannemann Engineering, Ausumgaard, ScrapTrans, Agro Korn and DryingMate.

The MuMiPro project has a total budget of 21 million DKK, and received a grant of 16 million DKK from Innovation Fund Denmark. Project participants include departments from Aarhus University and the Technical University of Denmark, Seafood Limfjord, Wittrup Seafood, Vilsund Blue, Engredo, Nofima, Limfjordsrådet, Danish Agro, SEGES Ecology and the development centre for free-range farm animals Udviklingscenter for Husdyr på Friland.

Mealworms are a serious alternative to other protein sources and can be fed biomass that is not readily edible by humans and animals. The insects are thus able to convert low-value products into valuable food and feed. Photo: The Danish Technological Institute



# Your health is in focus

Cheese, chicken, and bread rich in fibre: our bodies react differently to different foods. A group of experts from Aarhus University are surveying the relation between food and health.

What happens when you eat fermented milk products for breakfast? Hopefully, you will feel full and ready to meet the day's challenges – but what actually happens in your body when fermented soured milk products are digested? This is one of the major questions for food researchers all over the world: how does the human body react to intake of specific foods, and what is the importance of diets to our health? At Aarhus University, researchers are leaders within the area and during the last ten years, they have produced knowledge on e.g. why cheese is healthy and why bread rich in fibre is good for us.

The method applied by the researchers is known as metabolomics. When the body metabolises nutrients such as carbohydrates, protein and fat, different types of molecules are created that circulate in the blood and are secreted via the urine. The researchers will examine whether a certain kind of food is related to a certain change in the body by analysing and mapping the contents of these molecules.

## Eating cheese is good for you

Professor Hanne Christine Bertram from the Department of Food Science is one of the pioneers within this area. She was one of the first Danish researchers to apply this particular measuring technique in food research, and was recently awarded the EliteForsk Prize for her research.

- There is an incredibly huge focus on the understanding of the relation between diets and human health. We are currently examining new opportunities to improve and apply this method, and the metabolomics method is an excellent basis for investigating new and complex foods

or effects in the body, explains Hanne Christine Bertram. The connection between dairy product intake and health is one of the focus areas in recent years.

Researchers from Aarhus University are participating in research projects to investigate the background for the beneficial effects of dairy products. An examination of urine and faeces demonstrated that young and healthy males who consumed a diet rich in cheese had a higher excretion of the short-chain fatty acid butyrate, or butyric acid. This is particularly interesting, as receptors for butyric acid can activate the connection between the gut and the brain. In addition, butyric acid is known for activating the metabolism, reducing body fat percentage and contributing to the prevention of obesity.

## Dietary studies are increasingly valid

Another metabolomics focus area is dietary cohort studies in which test persons are to report what and how much they eat. Such information can be uncertain as the test persons, consciously or unconsciously, forget to register one or more foods or have difficulties assessing their actual intake. By identifying so-called biomarkers for intake of e.g. coffee or chicken, researchers try to establish objective methods to determine whether a person has eaten a certain type of food within the past 24 hours. This is done via a urine sample.

In the future, researchers from Aarhus University will continue their efforts within this area, and have a closer look at the importance of activity of the gut microflora in relation to nutrition and health.

Professor Hanne Christine Bertram from the Department of Food Science at Aarhus University was recently awarded the annual EliteForsk Prize for her research efforts within the relation between diet and health. The prize is awarded by the Ministry of Higher Education and Science to excellent researchers aged up to 45. Photo: Ditte Valente/Eliteforsk





# Beef may lower your blood pressure

Tenderness, juiciness and taste must all come together in the perfect steak. It is a well-known fact that ageing meat post mortem is crucial because natural enzymes and biochemical processes tenderise the meat.

Research from Aarhus University shows that ageing not only results in better meat, it also makes it healthier. Meat ageing develops peptides that can help lower blood pressure.

A peptide is an organic chemical compound consisting of short chains of amino acids linked by peptide bonds. Peptide development occurs when proteins and collagen are metabolised in the muscles. The longer the meat ageing period, the greater the development of beneficial peptides will be.

Peptides regulating blood pressure are also found in other types of food. The fact that they are found in meat is particularly interesting as the peptides are found in the meat's connective tissue. Connective tissue is also found outside the muscles, such as in large sinews, a waste product in abattoirs. If researchers can identify a method to collect this waste material and extract the beneficial peptides, the peptides could be used in medicine in the future.

However, do not switch from salad to beef just yet. The research project is based solely on laboratory experiments, and has not been tested on humans or animals.

# Cow genes can determine milk healthiness

Breeding can be used to promote health properties in cow milk. Recent research from Aarhus University and SEGES demonstrates that a cow's pedigree contributes significantly to determining the milk's content of various fatty acids.

The effect of fatty acids on health is still under debate, and research is still ambiguous, but current research shows that it is possible to achieve a health-promoting profile in milk fat by increasing the content of unsaturated fatty acids and reducing the share of saturated fatty acids – palmitic acid in particular.

- From our data we can see that genetic variations for individual fatty acid groups exist, and this means that we can "control" the nutritional content of milk by using semen from certain bulls, explains Senior Advisor Morten Kargo from the Department of Molecular Biology and Genetics, Aarhus University, who is also Special Consultant at SEGES. In Great Britain, dairy farmers already produce milk with specific properties. The milk is produced by using the feed to affect the fatty acid profile of the milk; breeding is not applied yet.

British consumers can buy a special type of milk with a reduced content of saturated fat compared to normal milk. The farmers producing this special milk have a contract with the dairy and are paid a higher price. In Denmark, farmers are ready to supply milk with a special fatty acid profile if there is a market for it, assesses Consultant in Organic Farming Arne Munk from SEGES.

- If there is a Danish demand for milk products with specific properties, it will be obvious to breed towards a more favourable type of milk and also to use the feed to produce milk with a health-promoting fatty acid profile. Danish dairy farmers are ready for this, says Arne Munk.

Read more about the results in the report from DCA "Fettsyreprofilen i mælk fra malkekøer" (Fatty acid profiles in milk from dairy cows), available for download at the DCA website (in Danish).

## About the project

The SOBcows project is an Organic RDD2 project coordinated by the International Centre for Research in Organic Food Systems (ICROFS). The project has been granted 7.4 million DKK by the Green Development and Demonstration Programme (GUDP) in addition to financial support from Bevaringsudvalget and the involved partners.

# Sweet, tasty and healthy – the new essence of juice



Photo: Colourbox

Many people like drinking fruit juice, which is both good and less than good. Fruit juice contains a number of beneficial vitamins but often has high sugar and low fibre contents. The challenge is to increase the nutritional value of the juice without spoiling the taste.

A team of scientists that included researchers from Aarhus University devised a solution to the problem of combining sweetness with healthiness by adding stevia for sweetness and  $\beta$ -glucans for fibre with a dash of lime to adjust the taste.

Stevia is a natural sweetener extracted from the *Stevia rebaudiana* plant. It provides sweetness to the juice.  $\beta$ -glucans are a type of fibres found in e.g. oats and increase the nutritional potential. The results show that the addition of lime to the juice could counterbalance the adverse impact on taste of the stevia and  $\beta$ -glucans. The taste of lime in the juice concealed not only the aftertaste of stevia but also the smell of staleness and metals imparted by the  $\beta$ -glucans.

The way is clear for the production of healthy and tasty juice in the future.



# Food with a pedigree is the new black

Information about the origin of a food can act as a stamp of quality if the food has a certain quality. Development of more provenance Danish foods will now be given an extra push.





Would you like to know where your food comes from? Would you prefer to buy a product that has a distinct history? There is a possibility that new Danish provenance products are on the way. In the future, it will be easier for farmers, municipalities, retailers and others to develop and market new food products with a distinct origin or history.

Researchers from Aarhus University are heading a new project, ProvenanceDK, in which municipalities and the food sector will collaborate on creating a new atlas of the possibilities for producing food with a distinct character. The project has been granted 13 million DKK from Innovation Fund Denmark.

Denmark already has examples of food with a geographical pedigree or a certain origin. Just think about North Sea cheese ("Vesterhavssost"), microbreweries and Stauning whiskey, to name but a few.

### Atlas of possibilities

The aim of the three-year project is to make a detailed map of the physical and sociocultural factors that can lay the foundation for development of new food specialties, i.e. food with a characteristic quality that is connected to the place where it was produced, with a special, local history, or made using specific animal breeds or plant varieties. The efforts will result in an atlas of all the potentials – an "Atlas of Possibilities".

The project will also develop business models for product types and initiate cooperation between municipalities, businesses and farmers with the aim of developing specific products and action plans.

With this project, the partners would like to address some of the problems that the Danish agriculture and food sectors face, such as fewer job opportunities and serious financial problems. Agriculture is also challenged by EU requirements with regard to the aquatic environment and biodiversity. These factors emphasise the need for geographical differentiation of the agricultural production.

Leader of the project Senior Researcher Chris Kjeldsen from the Department of Agroecology at Aarhus University explains:

- Development of specialty products can be a way to meet these challenges because the farmer can adapt his production to specific geographical conditions, create food products with unique qualities, thus creating added value, and contribute to regional employment.

### Food with a pedigree has several upsides

COOP is a project partner, and CSR Director Thomas Roland confirms that more producers want their products to refer to geographical origin:

- Development trends indicate that these product types will be even more successful in the future. Consumers are preoccupied with locally produced products – much more



Senior Researcher Chris Kjeldsen will collaborate with municipalities and the food sector on creating a new atlas of the possibilities for producing food with a distinct character. Photo: Maria Randima Brauer Sørensen

than their shopping carts suggest – and the share of organic products is significantly increasing.

There is also another aspect to why products produced locally or that have distinct qualities are successful, says Thomas Roland:

- It is about ensuring that customers consider the products trustworthy. In supermarkets, you do not buy from the producer himself, and customers use other indicators to establish trust in product quality and origin.

Niche products with a history are here to stay, says Thomas Roland:

- The trend is likely to continue, because it fits very well with the competitive pattern between retail chains, and our increasing affluence allows customers to prioritise these values.

### About the project

The ProvenanceDK project has a total budget of 20 million DKK, of which Innovation Fund Denmark has granted 13 million DKK. Besides Aarhus University (Department of Agroecology and the MAPP Centre) project participants include Ringkøbing-Skjern Municipality, Ringkøbing-Skjern Business Centre, Randers Municipality, Slagelse Municipality, Slagelse Business Centre, Business Region Midtvest, COOP Denmark, Meyers, Hørkram Foodservice and Randers Rainforest.

# When are **food labels** misleading?

How do you investigate if consumers are misled by clever food advertising? It is more difficult than you would think. Researchers from the MAPP Centre at Aarhus University are developing a useful method.



May a chicken from the Danish island Ærø labelled with its origin as an "Ærøkylling" be slaughtered off the island? Is it cheating if a producer claims that his products are "controlled by the authorities", if all the other products in the same category are also controlled by the authorities? In a new study, researchers from the MAPP Centre at Aarhus University have developed a method to determine if consumers misinterpret or not.

PhD student Trine Mørk from the Department of Management at Aarhus University, and co-author of the study, explains:

- Nowadays, we witness an increasing number of products. This means more competition to gain consumer attention. The result is increased potential for misinterpretation. Not only product information can be misleading; colours, fonts and all kinds of storytelling in relation to a product are potential misleading elements.

## Shopping by reflex

When consumers complain of being misled, it is actually not the case as they are aware that something is wrong. Therefore, you have to apply more subtle tools to investigate misleading information.

The risk of being misled increases if you are pressed for time, and when information is abundant in combination

with audible and visible noise. This particular situation often arises in the supermarket when you want to purchase your products in a hurry.

When working to develop the new method, the researchers examined consumer conception of different labels on chicken products.

- Briefly, the method consists of introducing two representative consumer groups to a number of labels, i.e. a piece of advertising text typically placed on the packing and describing the product. One group will only see the advertising text; the other group will see the advertising text together with brief, supplemental facts to explain the label, explains Trine Mørk.

- We then compared to see if the additional information changed consumer perception of the product. If additional information reduces the probability that the consumer will buy the product, or if it makes the consumer consider the quality to be lower, then we assess that the label is potentially misleading, she says.

The method has now been optimised and will be tested on other food products.

Read more in the report "Udvikling af metode til vurdering af vildledning i forbindelse med markedsføring af fødevarer", available for download from the DCA website (in Danish).



# Traffic light colours make consumers purchase climate-friendly products

Only eight out of 100 Danes can tell if a product is climate-friendly. However, new research from Aarhus BSS now shows that a simple red-yellow-green traffic light label can effectively help consumers choose products with the smallest carbon footprint.

Did you know that the climate footprint of frozen trout is more than double the size of the footprint of fresh trout? And do you consider this when shopping? Basically, it is difficult for consumers to determine the climate impact of specific products.

But now, new research from the Department of Management at Aarhus BSS - Aarhus University shows that, as a supplement to a carbon footprint label, adding red, yellow or green traffic light colours can effectively help consumers make a more climate-friendly choice. A green carbon label indicates a climate-friendly product with a low carbon footprint, and a red label indicates the opposite.

- A traffic light colour scheme on a label makes it simple and easy to interpret - unlike, say, the letter-labelling on kitchen and home appliances, where many consumers find it difficult to interpret whether e.g. A+ is good when there are A+++ labels as well. But the consumers reacted positively to the green, yellow and red colours in our survey, explains Professor John Thøgersen, who conducted the study along with Kristian Steensen Nielsen.

The researchers used coffee as test product. Here the traffic light carbon label influences the consumers' product choice to a high degree - as does price, the Danish organic label "Ø-logo", or a special certification such as the one used by Max Havelaar.

The researchers also tested if the effect of the carbon label on consumer choices depends on their concern about climate change - which it does.

- It is only if you care about the climate that a carbon label can help you achieve what you want, namely to purchase climate-friendly products, says John Thøgersen. The traffic light colours makes the carbon label a more easy-to-use and therefore more effective tool for these consumers.



Photo: Jesper Rais

## Popular thematic meeting on mink in Foulum

Each year on the third Tuesday in September, Aarhus University in Foulum hosts the annual thematic meeting on mink. Researchers inform about current research projects and present recent results regarding mink production.

In 2016, a record number of guests participated, including more than 180 fur breeders, advisors, veterinarians, researchers and other interested parties.

You can read more about the researchers' efforts and results in the DCA report "Thematic meeting on current mink research", available for download at the DCA website (in Danish)



Photo: Linda Sørensen

## Open farm event was a huge success

In keeping with tradition, Aarhus University in Foulum hosted an open farm event in September 2016 so that children and adults could learn more about food and agricultural research and production. At the Danish Cattle Research Centre, visitors had a chance to get close to cows and to pet calves, see the robotic milking systems in action, learn more about cattle research, play in a straw maze and enjoy food samples from Arla.

At the organic farming facilities, visitors were introduced to pregnant, organic sows in the fields and organic poultry among the willow. Drones were presented, there were juicy apples from Årslev and last, but not least, impressive machinery in the fields.



Photo: Tobias Frandsen, Foodproject.dk

## Research addressing all senses at the Food Festival

For the fifth year running, the Food Festival 2016 welcomed more than 30,000 visitors at Tangkrogen in Aarhus in September. The visitors were given the opportunities to see, smell and not least taste a broad range of foods ranging from dessert beer and seaweeds to black oats and insects.

Naturally, the Department of Food Science, Aarhus University, had a stall presenting current food research. Ideally located at the centre of the festival area, the food stall had many visitors right from the opening.

Researchers hoped to arouse the visitors' senses and introduced projects that enabled visitors to see, smell and touch.

Food Festival 2017 will be held from September 1-3, 2017.



## Sign up for the newsletter

The weekly DCA newsletter presents agricultural and food research and informs about future events.

Read more at [dca.au.dk/en](http://dca.au.dk/en), and sign up for the newsletter.



## European visitors expressed great enthusiasm for AU Foulum

The food and agricultural sector is one of the areas where collaboration between research and industry is strongest. Expertise and familiarity with practical issues are worth their weight in gold for companies. In return, it is crucial for researchers that their knowledge is exploited for the benefit of industry.

This was the background for DCA collaborating with a number of local partners on September 14–15, when they hosted a major international biorefining seminar.

The event attracted researchers and companies from seventeen countries, and provided visitors with an opportunity to attend a number of workshops where they could meet European colleagues and cultivate networks. These workshops addressed issues such as new agricultural systems, the conversion of biomass to fuel and other high-value products, and the use of green biomass for producing protein for pigs and poultry.

Speakers at the seminar included representatives from the LEGO Concern, who talked about the need for bio-based plastic, the Bio-based Industries Consortium (BIC), and the European Commission.



## Major conference on agriculture in the future

In June 2016, Aarhus University hosted the international Conference on Agricultural Engineering 2016, which focused on the role of technology in agriculture of the future.

It was the first time this conference was held in Denmark, and it attracted more than 600 researchers and other professionals from the agricultural sectors worldwide.

The conference addressed current themes and challenges within automation, environment and food safety.

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### DCA in social media

DCA has Facebook and LinkedIn profiles providing the most recent results from food and agricultural research at Aarhus University.







# DCA reports on food and agriculture

DCA – Danish Centre for Food and Agriculture currently publishes reports on research results and experiments targeted at Danish conditions. The reports are mainly based on commissioned research-based policy support.

In 2016, DCA published the following reports – all are available for **free download at the DCA website**.

## Food and consumption

- Food and healthy ageing in a life perspective
- Consumer behaviour when choosing Keyhole labelled products in retail
- Development of a method to assess misinformation in relation to marketing of food
- Shelf life labels in relation to food products
- The effect of referred nutrition, food and meals for the elderly in their own homes on life quality, including the joy of eating and functional capacity

## Livestock production

- Fatty acid profile in milk from dairy cows
- Free range slaughter pigs
- Thematic meeting on current mink research
- The genomes of old Danish breeds
- Employees in Danish livestock production: Who are they, and what are their roles in relation to ensuring excellent animal welfare
- Communication on animal welfare
- Nordic ISAE 2016

## Agriculture and crop production

- Establishing a status for the prevalence of herbicide resistance in Denmark (2013-2015)
- Environmental life cycle assessment of Danish cereal cropping systems
- Nutrient balances and nutrient surplus in agriculture 1994/95-2014/15
- Applied crop protection 2015
- Biogas Taskforce – development and optimization of biogas production in Denmark
- Mapping sustainability criteria for the bioeconomy
- Green Biomass