

The National Food Institute conducts research to understand how the food we eat affects our immune system and metabolism - and how our gut bacteria influence the development of e.g. food allergies.

📷 Lactic acid bacteria. John Walsh/Science Photo Library/Scanpix

# The key to good health lies in your gut

Bacteria in the gut affect the risk of developing lifestyle diseases such as type 2 diabetes and cardiovascular diseases. The National Food Institute conducts research in order to understand how bacteria in the gut affect our sensitivity to substances which we get through our food.

Most people know how important a healthy gut is to our well-being. The gut is a highly specialized organ that hosts more than 10,000 billion bacteria. As such, we have more bacteria in our gut than we have cells in our body.

It has been said that if we unfold our intestine, its surface area will be the size of a tennis court. Even though recent research shows that the intestine may be a little smaller than this, it is still larger than our skin and is thus the largest surface in our body. This is important to understand as a significant part of the communication between the bacteria in the gut, the substances in the gut, and our body takes place via the surface of the gut.

“Over the past years, we have witnessed an explosion in our knowledge of how the interaction between our diet, the bacteria in our gut, and our immune system affects the risk of developing lifestyle diseases. This huge leap is especially due to the fact that DNA analyses have become faster and cheaper. Moreover, new options within information technology have given us the opportunity to handle the large quantities of data which the bacteria’s DNA offer,” explains Professor and Head of Research Group Tine Rask Licht from the National Food Institute.

## Whole grains reduce inflammation in the body

Since 2013, choosing whole grains instead of refined grain products has been one of the official food-based dietary guidelines, and research results from the strategic research centre Gut, Grain and Greens (3G) backs up this guideline. With Tine Rask Licht at the helm, the 3G Centre has conducted one of the most comprehensive dietary intervention studies of its kind. The research project has examined how whole grains in our food affect the bacteria in the gut as well as a number of health-related biomarkers.

“The study shows that there is a good scientific basis for the authorities’ dietary advice, and it makes good sense to replace refined grain products such as white bread and white pasta with various types of whole grain products,” Tine Rask Licht says. She adds: “We can show that an intake of whole grain products reduces inflammation in the body, which particularly constitutes a risk for overweight people who are susceptible to developing cardiovascular diseases and type 2 diabetes.”

## Gluten can stay on the menu

Rye in particular seems to have a positive effect on reducing inflammation. In addition, whole grains are more satiating, which can help people to lose weight.



The study also shows that the much-discussed gluten protein is not unhealthy - except for the small part of the population that suffers from either celiac disease or is allergic to wheat protein. Gluten is found in e.g. wheat, rye, and barley, and replacing such foods with alternatives that are low in gluten, including oat, rice, maize, and quinoa, does not reduce inflammation in the body. However, a diet low in gluten causes the beneficial bifidobacteria - which live on the special types of fibre and polysaccharides in grain - to disappear from the gut. As such, there is no reason to remove gluten from your diet if you are generally in good health.

**On the way towards personalized dietary advice**

The 3G Centre has been very important in promoting the interdisciplinary cooperation between a number of Danish research environments with different expertise within the areas of bacteria in the gut, diet, and lifestyle diseases. Researchers at the National Food Institute and at the University of Copenhagen are still analysing the huge amount of data from the project, and Tine Rask Licht has a hypothesis:

"We believe that the bacteria in the gut play a big part in why people react differently to the same diet. In the future, this knowledge may lead to personalized dietary advice and medication based partly on faeces samples, which can be brought to the doctor's office."

**Faeces can save lives**

The recent knowledge of gut bacteria does not only back up the authorities' dietary advice. It can also save lives and change the treatment options within the healthcare system.

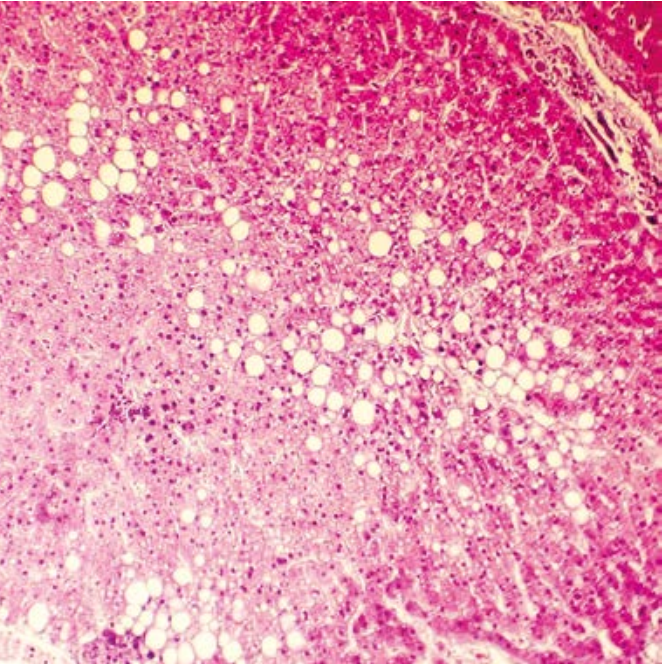
The National Food Institute conducts research with Aarhus University Hospital, among others, in how faeces from healthy people can cure the life-threatening gut disease *Clostridium difficile*, which is currently being treated with antimicrobials.

"Staff at Aarhus University Hospital have experienced that nine out of ten patients get well in as little as a few days after a faecal transplant. This is important because some of those patients cannot be cured by antibiotic treatment," Tine Rask Licht says.

Today many of the patients are treated with two or three types of antibiotics. However, treatment with faeces may be an excellent alternative in the future. The high percentage of very sick patients who get well because of a faecal transplant is challenging the general assumption that some patients are too sick to get a transplant.

**The future lies in the gut**

Until now, the researchers have only solved a small part of the complex mysteries of the gut, and in the future, the National Food Institute will have an increased focus on understanding how the different bacteria in our gut affect our sensitivity to e.g. the chemicals and hormones, which enter our body via foods and packaging.

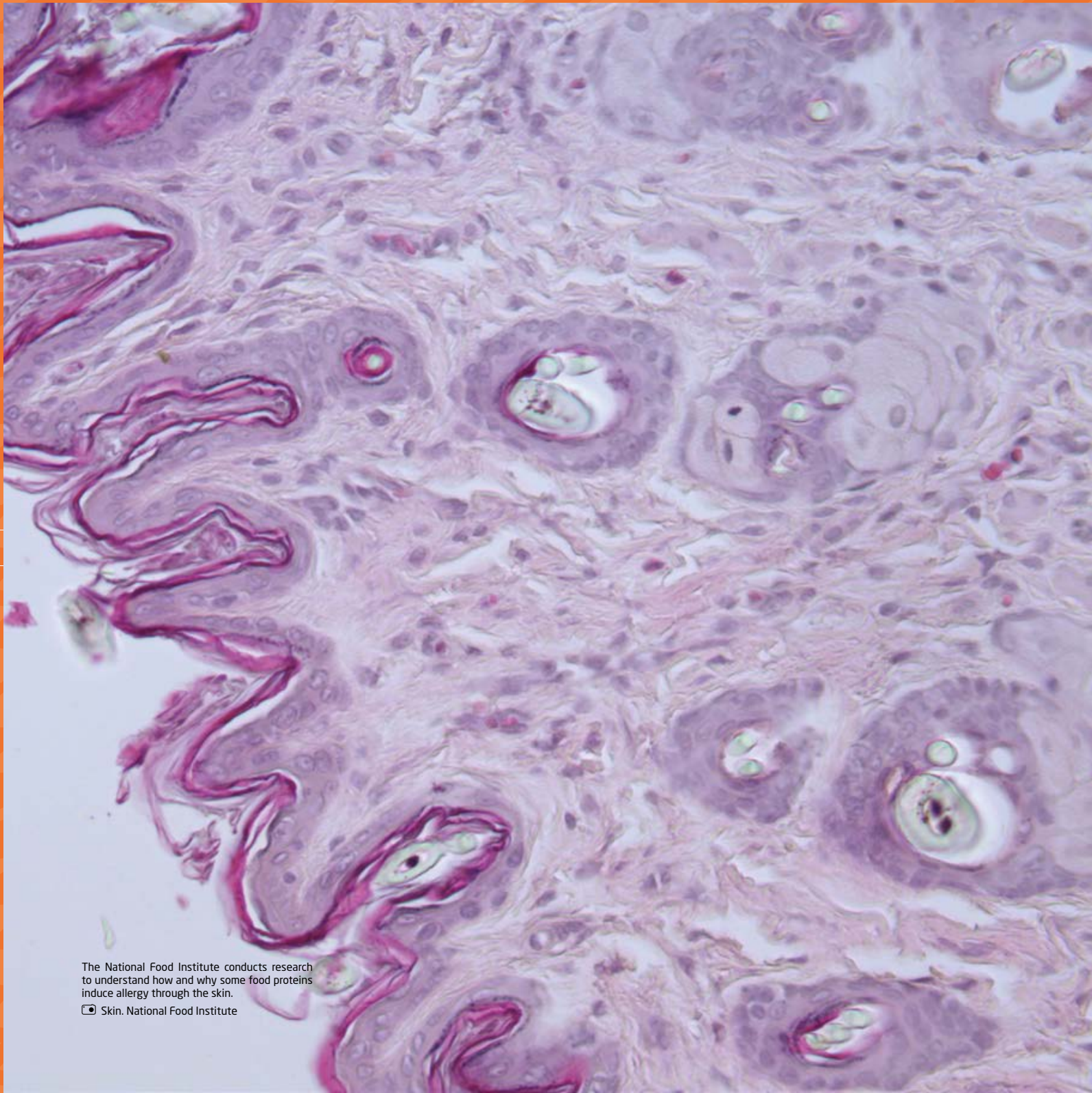


Research from the National Food Institute has showed that the intestinal microbiota may influence processes in the liver.  
© Histological section of the liver. Shutterstock

“The ambition is at to gain an even greater understanding of the complex bacterial composition in the gut and its influence on health. This can lead to personalized dietary advice and medication. At the National Food Institute, we will explore how genetically modified bacteria may be used as an alternative to medication, and how advanced methods for encapsulation of bacteria can promote the colonisation of desirable bacteria in the gut.”

Tine Rask Licht  
Professor and Head of Research Group





The National Food Institute conducts research to understand how and why some food proteins induce allergy through the skin.

📷 Skin. National Food Institute

# Food allergy may develop through the skin

Food allergy not only develops after ingestion of food. What we put on our skin and in our hair can also cause allergies. The more knowledge we have about how allergies develop, the better the options for preventing and treating them will be. The National Food Institute works to prevent and treat allergies and to promote tolerance.

Millions of people around the world suffer from food allergies, and, in the worst cases, the condition can be fatal. Therefore, the National Food Institute conducts research on how to prevent, treat, and manage food allergy.

When people become allergic, it is mostly – with a few exceptions – the proteins, which people develop allergies towards. The body can create a type of antibodies whose original purpose was to fight parasites. When such antibodies start reacting to foods that are normally harmless, a faulty response has occurred in the body, which then causes the allergy.

Why do people primarily become allergic to certain foods and not to others? The basis of the research is to understand why some food proteins are allergenic and others not. Therefore, the researchers study both the allergenic and tolerogenic properties of proteins – i.e. the properties that contribute to allergy and tolerance development, respectively.

It is important to explore both aspects because this provides the researchers with the knowledge they need to develop new strategies that can prevent and treat allergies. One purpose of the research is to change the structure of a protein, so that the protein may still give us tolerance but not cause allergy.

## Scratches and inflammation increase the risk

The Institute’s research is conducted through rat experiments. This provides the researchers with the opportunity to examine what happens when the animals are exposed to the given protein for the first time. Almost all research related to the sensitization phase of allergies (where the allergy occurs) is conducted on animals as it is impossible to retrospectively go back in a person’s life to see how this person developed the allergy. However, by studying sensitization in the animals, the researchers can obtain knowledge that will help them to prevent and treat allergies.

A number of the Institute’s research projects relating to exposure suggest that we are likely to develop allergies through the skin, i.e. when allergenic substances come into contact with your skin from the environment or from the cosmetics we use, including shampoos, conditioners, etc. The researchers are, therefore, working on projects relating to skin sensitization, which focus on examining how and why some food proteins can cause allergy through the skin.

“We know that the nature of the skin affects whether you will develop allergies. If the barrier of your skin is broken, you may be at greater risk. Furthermore, if you have an inflammation

such as in the skin disease atopic dermatitis, you are also more exposed,” Senior Researcher and Head of Research Group Katrine Lindholm Bøgh says.

“It would be amazing to have the resources to develop tools and techniques to retrospectively diagnose how the patient has developed his or her allergy: Did the person develop the allergy after food ingestion or through the skin? Such knowledge would be of great significance in respect of both the treatment and prevention strategies, which would make life easier for patients who are predisposed to developing an allergy – or who are already allergic,” Katrine Lindholm Bøgh says.

#### **If we haven’t eaten it, we shouldn’t put it on our skin**

How easy or hard it is to become allergic to a substance that we put on our skin is among other things dependant on the properties of the proteins.

Proteins that have been used in a bottle of shampoo may have been modified. The manufacturer of the shampoo may have used processed food proteins which have been made more emulsifying and foaming through hydrolysis. Because the proteins have been modified people may be at greater risk of developing an allergy to it. This is because we have not previously eaten the exact same protein. The immune system sees it as a brand new protein to which the body has not yet developed any tolerance.

Modified food proteins in cosmetic products thus constitute a greater risk than non-modified proteins.

“It is very important that you have eaten a food protein before you put it on your skin. Otherwise, it could cause the immune system to see it as a new substance with various consequences. You can become allergic to a substance when you are exposed to it for the first time, but you are also at risk of losing tolerance to something which you were previously able to tolerate,” Katrine Lindholm Bøgh explains.

“From Japan we know examples of people who have used a soap with modified wheat protein and subsequently became allergic to the modified wheat protein, while others also became allergic to non-modified wheat which they tolerated before using the soap,” Katrine Lindholm Bøgh says.

Whether a protein can cause an allergy also depends on the context in which the protein occurs. It probably matters whether the protein occurs in a soap, lotion, or oil. Therefore, the researchers are studying what influence the context – or matrix – has on developing an allergy.

#### **Interaction between industry and authorities benefits consumers**

The researchers closely collaborate with the industry in respect of testing products and helping to develop innovative solutions.

One example is birch sap, which many people with a birch pollen allergy have started to drink to reduce their allergic symptoms. There is no scientific evidence of the positive effect of birch sap yet, and, therefore, the researchers are testing birch sap by using animal studies to find science-based evidence of the effect of the sap.

Another example is the Innovation Fund Denmark project AL-LEVIA TE, that aims to develop new products which can prevent cow’s milk allergy and treat peanut allergy. The new products would be able to promote people’s tolerance to the proteins in food that can cause allergies. The aim of the project is to develop partly ingredients for an infant formula that prevents babies and toddlers from becoming allergic to cow’s milk, partly a drug candidate for the treatment of peanut allergy.

The recommendations and risk assessments which the Institute delivers to the Danish Veterinary and Food Administration and the Danish Environmental Protection Agency also help the authorities to decide what ingredients should be allowed in the products on our supermarket shelves.

“**The ambition is** to contribute to fewer people becoming allergic in the long run, that more people can get treatment, and that people with allergies can manage their allergies in an easier way. It would increase the quality of life if allergy sufferers could go to the supermarket knowing which products are safe to buy and use, and which products they must avoid. Moreover, it is our ambition to get a better understanding of the connection between stress and allergy. We know that the risk of developing allergic reactions is greater when we are exposed to the allergen while we are physically or mentally stressed. As both stress and allergy are on the rise, it is obvious and essential to look at the connection between the two phenomena, which both have a negative effect on our quality of life.”

**Katrine Lindholm Bøgh**

Senior Researcher and Head of Research Group



# A 360° view of the effects of foods

By exploring both the beneficial and the harmful health-related properties in foods, consumers and authorities become better equipped to predict the health effects of individual foods, nutrients, and diets. The National Food Institute is leading in the area of risk-benefit assessments.

Fish is an important source of beneficial fatty acids and vitamin D, but fish can also contain harmful heavy metals such as methylmercury. Nuts contain healthy fats, but they can also contain carcinogenic moulds (aflatoxins). And red meat is one of the main contributors when it comes to unhealthy intake of saturated fat, but at the same time it contains important dietary iron.

“Risk-benefit assessments allow us to quantify, compare, and measure the health effect of specific foods or food groups,” says Senior Researcher and Head of Research Group Morten Poulsen, whose group heads up the International Network on Risk-Benefit Assessment of Foods.

## What is a healthy diet?

The National Food Institute, which has a long tradition of research in the field of food safety, is leading within the area of risk-benefit assessments.

Among other things, risk-benefit assessments are used to quantify the health impact of eating in accordance with the official food-based dietary guidelines or following a specific diet compared to what an average Dane eats. Furthermore, the calculations make it possible to explore segmented population groups such as women of childbearing age or men over 50 years, and examine what happens to your health if one type of food is replaced by another.

## Replacing steak with fish results in better health

A risk-benefit assessment conducted by the National Food Institute showed that the health of the average Dane – and in particular men over 50 and women of childbearing age – would benefit if people replaced some of their meat intake with fish and thus reach the recommended weekly intake of 350 grams of fish.

“The Institute’s calculations show that the Danish population can gain up to 7,000 healthy years of life annually if all Danes eat fish instead of red meat. However, the health benefit depends on the type of fish the consumer chooses. The greatest health benefit comes from eating fatty fish (such as herring and mackerel) or a combination of fatty and lean fish (such as plaice and pollock). The benefit is smaller if the consumer eats only lean fish”, Morten Poulsen says.

If consumers decide to eat only tuna, the overall assessment shows a significant health loss. Tuna is low in beneficial fatty acids and can have high concentrations of methylmercury. The health loss is assessed to be particularly high among women of childbearing age as a large intake of mercury can damage unborn children’s brain development.

## Interdisciplinary cooperation is the key

Risk-benefit assessment is a relatively new discipline that draws on a number of disciplines such as nutrition, toxicology, microbiology, and epidemiology.

Risk-benefit assessments from the National Food Institute are used, e.g., to assess the effect of fortification, production methods, and dietary recommendations.

Red lettuce. Colourbox





The National Food Institute develops models to be used in risk-benefit assessments, which evaluate foods' harmful and beneficial effects.

📷 Salmon. Colourbox

In the assessments, the researchers often calculate the beneficial and harmful health effects by using the health metric disability-adjusted life years (DALY). DALY is a measure of how many years people will have to live with a reduced quality of life due to illness, and/or how many years are lost because a person dies earlier than expected.

#### **Intervene to ensure as few people as possible become ill**

Besides risk-benefit assessments, health metrics can be applied to explore the burden of disease in the population caused by different chemicals and disease-causing microorganisms, contaminants in food, and dietary risk factors such as a high intake of sugar or a low intake of fruit and vegetables.

Studies show that Campylobacter is the foodborne bacterium that makes the biggest contribution to the burden of disease in Denmark. Even in countries like Denmark, which have excellent monitoring systems, it is difficult to determine how many



The National Food Institute calculates the burden of disease of various foodborne diseases and can compare risks associated with different foods.

📷 Raspberry. Colourbox

people are affected by a foodborne disease every year. Many of these illness cases often stay under the authorities' radar because not all patients seek medical care, not all doctors seek a sample, and not all samples are analysed.

Researchers at the National Food Institute have estimated the burden of disease of the three foodborne pathogens Salmonella, Campylobacter, and verotoxin producing Escherichia coli (VTEC). These show that Campylobacter ranks highest followed by Salmonella.

The results help the authorities and food producers to assess where to intervene so that as few people as possible get sick from the food they eat.

"Risk-benefit assessments have given us an effective tool to examine the health effects in the population, promote healthy eating habits, rank food-related risks, and in the production of foods," Morten Poulsen says.

**“The ambition is** to use and streamline even more data so that the risk-benefit assessments can reach the public sooner. This would, for example, make it possible to conduct a risk-benefit assessment of different diet trends as soon as they reach the consumer. Today it takes too long, and the trends are usually over by the time the results are ready. We also hope to build a bridge between the industry, consumers, and authorities through even more interdisciplinary cooperation when it comes to assessing both the harmful and the beneficial.

**Morten Poulsen**

Senior Researcher and Head of Research Group

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