Producing palm oil substitute from corn waste

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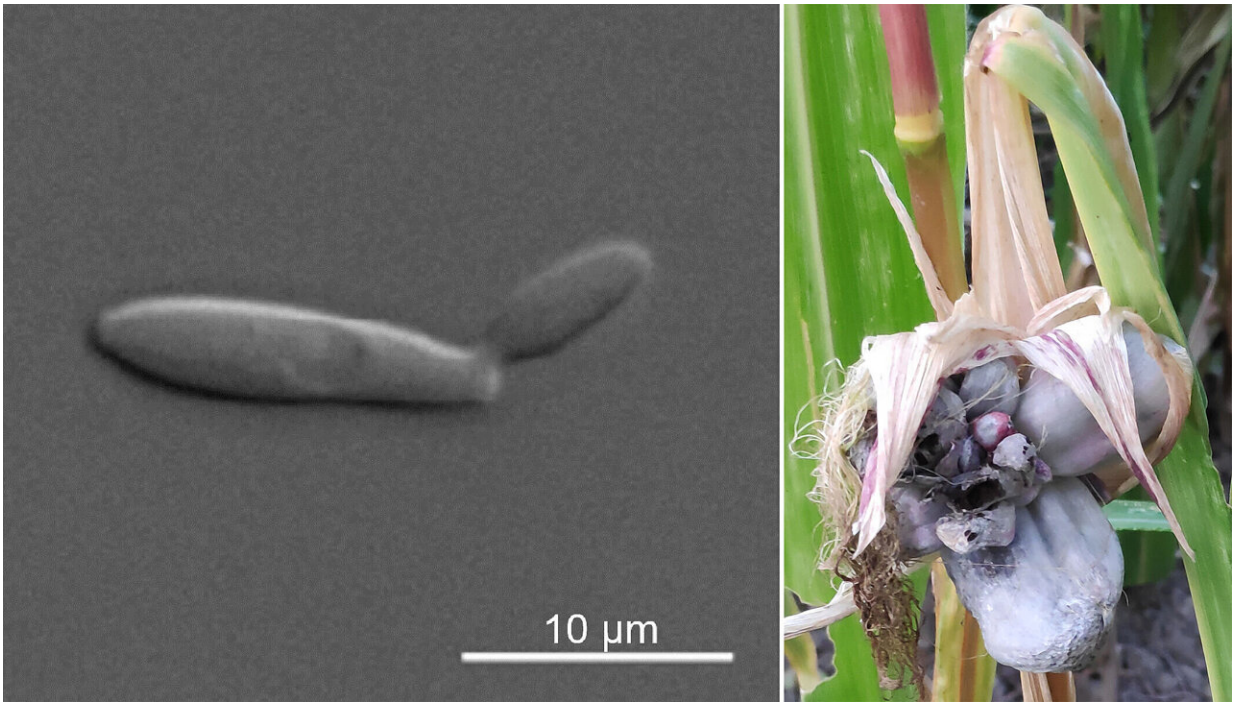

The unicellular fungus Ustilago maydis (left: microscopic image) is the pathogen that causes the plant disease corn smut (right: image of a plant with the disease). The fungus can be genetically modified to produce a microbial oil. Credit: HHU / Magnus Philipp

Is a sustainable, local alternative to palm oil possible? The research consortium NextVegOil from Aachen, Bochum, Düsseldorf and Münster is aiming to develop a commercial-scale process for producing a

microbial oil similar to palm oil from agricultural waste in the future. A specially modified unicellular fungus will do the work. In the project, which is funded by the Bioeconomy Science Center (BioSC) and involves two research groups from Heinrich Heine University Düsseldorf (HHU), the aim is then to produce vegan cheese based on the palm oil substitute in cooperation with a start-up based in Berlin and Bonn.

Palm oil is one of the most widely used vegetable oils. The low-cost product is used in many sectors of the food industry and can also be used in the production of biofuels.

However, palm oil production has far-reaching ecological consequences: Large areas of tropical rainforest are being cleared to enable the planting of palm tree monocultures, resulting in the loss of valuable ecosystems and severely impacting biodiversity. For example, this poses a serious threat to the orangutan population on the Indonesian islands of Borneo and Sumatra. In addition, the palm oil produced in the tropics needs to be transported over very long distances to consumers in Europe and the U.S., with corresponding consequences for the environment. The use of palm oil for biofuels also competes with food production.

It would be significantly more sustainable, resource- and eco-friendly to produce a product similar to palm oil on a regional basis near to consumers—from plant residues that cannot be used cost-efficiently either as food products or as chemical raw materials for industry. This is exactly the objective being pursued by the NextVegOil research consortium based in North Rhine-Westphalia (NRW).

Using the fungus Ustilago maydis, the researchers have found a way to produce a microbial oil which closely matches palm oil—i.e. it has a similar composition of fatty acids, which determine its properties—meaning that it is likely to be suitable for use in food. In the

course of the project, the aim is to establish the fermentation of corn stover—which cannot be eaten or used as animal feed—on a large scale.

The agricultural industry is not well-disposed towards Ustilago maydis otherwise: The unicellular fungus causes the plant disease "corn smut"; this fungus is however harmless to humans and is even considered a delicacy in Mexico. "While it is a disadvantage for some, we can utilize it to achieve our goals: As the fungus is so well adapted to corn, it is also ideally suited to recycling corn residues," says Professor Dr. Michael Feldbrügge from the Institute of Microbiology at HHU, who is one of the researchers involved in the project in Düsseldorf. He continues: "There has already been a significant amount of genetic and biotechnological research into the fungus, which naturally also produces other biotechnologically relevant substances such as biosurfactants, so we know where we can use it for our purposes."

Professor Feldbrügge's colleague, Professor Dr. Markus Pauly from the Institute of Plant Cell Biology and Biotechnology at HHU, adds: "Corn also offers breeding potential in terms of optimizing the plant residue for this kind of metabolic transformation by the fungus without transgenic methods."

The researchers have found out that Ustilago maydis can also produce oil instead of surfactants if the synthesis process of the fungus is interrupted at a specific point at genetic level. This has already been demonstrated on a small scale. The fatty acid profile of this oil is very similar to that of palm oil, making it highly promising as a substitute product. In the next few years, the researchers in Düsseldorf are aiming to optimize the fungus so that the oil it produces matches the properties of palm oil even more closely. They are also working on biotechnological processes to ensure optimum conversion of the corn stover raw material in the fermenter.

The project partners at Aachen University of Technology (RWTH) are working on the next steps towards establishing an economically feasible production process for the palm oil substitute. Once the optimum parameters for the corn biomass conversion and the fungus have been found in Düsseldorf, it will be possible to move on to implementing the fermentation process on a commercial scale. The oils produced in this microbial process must then be precisely analyzed and purified to ensure they meet food standards.

In addition to the biological and technical aspects, there is also an economic aspect: In parallel with the ongoing activities, researchers in Bochum are analyzing the cost-efficiency of the process chains and investigating the markets on which the palm oil substitute can be sold. Piloting the product is the focus of project partner Formo, a biotech start-up, which aims to produce vegan cheese using the microbial oil.

"It is important to everyone involved in the project that we can offer a sustainable product as an alternative to conventional palm oil: a regional product, made from renewable raw materials, with a good carbon footprint. And also a product which does not compete with food production, as the starting materials are residues that are generated anyway," say Professor Feldbrügge and Professor Pauly.

The NextVegOil project

Two biology institutes at HHU are involved with the project for the microbial production of a palm oil substitute: The Institute of Plant Cell Biology and Biotechnology (Professor Dr. Markus Pauly) and the Institute of Microbiology (Professor Dr. Michael Feldbrügge) are working on the optimization of the corn biomass, its conversion using Ustilago maydis and the optimization of the oil production.

The Chair of Biochemical Engineering at RWTH Aachen, headed by

Professor Dr. Jochen Büchs, is concentrating on the fermentation of the oil. At the University of Münster, researchers at the Institute of Inorganic and Analytical Chemistry led by Professor Dr. Heiko Hayen are analyzing the composition of the oils produced. Professor Dr. Stefanie Bröring from the Chair of Entrepreneurship and Innovative Business Models at the Ruhr University Bochum is examining the economic and marketing aspects. Finally, the biotech start-up Formo, based in Berlin and Bonn, is aiming to use the palm oil substitute for the production of vegan cheese.

Provided by Heinrich-Heine University Duesseldorf