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News Release

Freising-Weihenstephan, 3 February 2011

From cellulose to sugar:

Microbiologists at the TU Muenchen aim to optimize bio-ethanol production

Food versus fuel - this rivalry is gaining significance against a backdrop of increasingly scarce farmland and a concurrent trend towards the use of bio-fuels. Researchers at the Technische Universitaet Muenchen (TUM) are helping to resolve this rivalry: They are working to effectively utilize residual field crop material – which has been difficult to use thus far – for the industrial production of bio-ethanol. They took a closer look at bacteria that transform cellulose into sugar, thereby increasing the energy yield from plants utilized. If this approach works, both bread and bio-fuel could come from the same harvest in the future.

The age of diesel and gasoline is approaching its inevitable end. However, one of the alternatives, bio-ethanol made from plant material by way of microorganism fermentation, is under attack. Until now, bio-ethanol has been produced from crops such as wheat, sugar cane or corn, or more accurately, from the sugar these crops contain in the form of starch. However, when field crops are used for the production of bio-ethanol, they are no longer available as food. Researchers at the TUM Department of Microbiology are working on a solution to this dilemma. The idea: Make the sugar stored in the stems and leaves of plants in the form of cellulose available for bio-ethanol production. “It is our goal to take the cellulose, which has so far hardly been used, and turn it into sugar on an industrial scale, which can then be processed to bio-ethanol,” says microbiologist Dr. Wolfgang Schwarz.

But it is not that simple. As the main constituent of plant cell walls, cellulose is responsible for the stability of the plant during growth – and it is therefore extremely sturdy. Sugar molecules form cellulose molecules, which are connected in robust chains to form extremely resilient fibers. Breaking down the stable cellulose into sugar is difficult. Luckily, nature provides enzymes that can do just that. They are found in bacteria, for instance, that live in the stomachs of cows. In these natural "bio-reactors" they help digest grass and release the sugar. However, the bacteria take a very long time to break down the cellulose. Before cellulose can be transformed into bio-fuel in an efficient and cost-effective way on an industrial scale, the process must improve significantly.

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The TUM Department of Microbiology has taken on this task. On the one hand its scientists search through nature's immense microbial diversity for as yet unknown cellulose-degrading enzymes. On the other hand they are isolating new "cellulose-eating" germs from nature in order to examine them more closely. Dr. Schwarz's work group is now taking a closer look at the most promising of these bacteria, *Clostridium thermocellum*. This soil bacterium has altogether over 70 enzymes that it uses to degrade different parts of plant cell walls. Thanks to this "toolbox" the bacterium can adapt perfectly to its environment. Depending on whether it lives in straw, leaves or waste wood, *C. thermocellum* produces a different, effective enzyme complex on its surface to degrade the cellulose.

The TUM researchers are now testing this principle in the lab. They want to use the bacterium's toolbox to find ideal enzyme combinations for the industrial degradation of cellulose. To do this they firstly identified the most powerful enzymes and generated them in a test tube. These components were then combined to produce multiple variations, the best of which were selected by the microbiologists. Doctoral candidate Jan Krauss spent three years working on this: "We are now optimizing the most effective combinations for industrial use. Our ultimate goal is to develop a specialized degradation tool for every individual plant waste material containing cellulose. With a bit of luck we will find the perfect enzyme mixtures, which can then become established in bio-ethanol production facilities."

With this research program the TUM scientists are in sync with current industrial trends. Süd-Chemie AG is building a pilot plant in Straubing to convert the biogenic residual product straw into ethanol.

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Background:
Jan Krauss's doctoral thesis "Enzyme Complexes" was funded by the German Federal Ministry of Food, Agriculture and Consumer Protection for three years. For his postdoctoral research Dr. Krauss received a grant of 94,000 Euros for one year through the EXIST start-up program of the Federal Ministry of Economics and Technology. The program supports entrepreneurs from universities and research institutions who want to turn their start-up ideas into business plans.

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