Anaerobic fungi: A bright future for bioenergy applications?

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Anaerobic fungi inhabit the digestive tract of various herbivore animals. They are recognized for playing a major role in the breakdown of lignocellulosic biomass by physical penetration and unique extracellular cellulolytic machinery. The unique metabolism, intensified degradation and syntrophic association with other microbes makes anaerobic fungi more beneficial for enhanced anaerobic digestion in various biofuel producing agro-industries.

Anaerobic fungi (AF) are one of the prominent members of the rumen and digestive tract of various ruminants, where they play a crucial role in initial degradation of lignocellulosic biomass (LCB). The study of anaerobic fungi has become the major interest of researchers worldwide for their ability to degrade lignocellulosic biomass by producing extracellular cellulolytic enzymes and for applications in biofuel production. AF are the initial degraders of plant biomass in rumen, by physical breakdown of lignocellulose and extracellular enzymatic secretion. AF can physically breakdown the lignin by invading the lignocellulose with the help of hyphae. AF produces extracellular carbohydrate active enzymes and a multiprotein complex called cellulosome. This unusual feature of external cellulosome has not been observed in other lignocellulose degrading fungal species.

Methanogenic archaea and anaerobic bacteria are known to have a synergistic correlation with anaerobic fungi, which prevents the product inhibition in AF. The lignocellulose degrading activity, growth and carbohydrate utilisation rate of AF was observed to increase in presence of methanogens.
The bio-augmentation of anaerobic fungi may create a new opportunity for enhanced methane production from various agricultural wastes. Several attempts have been undertaken to improve the LCB degradation by augmenting AF in anaerobic biogas digester. However, the achievement of substantial fungal growth in a digester is still a challenging objective. Use of methanogen and AF co-culture is the promising approach for enhanced biomethanation from agricultural lignocellulosic wastes.

In a new project within ICBT's Environmental Biotechnology Lab, we aim to explore anaerobic fungi for distinct enzymatic activity and industrially valuable novel cellulolytic enzymes for enhanced bioprocessing of LCB. The interaction of the different organisms in the rumen especially between AF and methanogenic archaea are of great interest. This study could be crucial for future applications such as more efficient degradation of LCB, biofuel production as well as methane mitigation in ruminants to reduce greenhouse gas emissions. Anaerobic fungi have been growing semi-continuously for millions of years in their ancestral habitats. Mimicking this natural process to cultivate the AF semi-continuously in anaerobic digester for biofuel production shows great promise.

Cooperation with international project partners

The combined efforts of the most prominent research groups in Europe are uncovering the hidden potential of anaerobic fungi for its enhanced degradation of lignocellulose and biofuel production. The research group at Innsbruck University, Austria, headed by Prof Heribert Insam are experts in anaerobic microbiology, molecular detection methods and phylogenety, whereas, the research group at Bavarian State Research Center for Agriculture (LfL), Germany, led by Dr. Michael Lebuhn is skilled with microbial culturing, anaerobic digestion and bioinformatics. The close cooperation of the different research groups brings together expertise from different scientific fields to investigate the potential and biotechnological benefits of AF. Further information about this project you find on the project-website:
www.hipoaf.com

Fig. 1: The microscopic image of *Orpinomyces joyonii* degrading the rice straw was captured by Akshay Joshi at Aghrkar Research Institute, Pune, India.

Coffee without the bean

Coffee Excellence Center

Fig. 1: A fresh and aromatic cup of Atomo's molecular drip coffee

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Researchers at the Humboldt University in Berlin (Bunn *et al.* 2015) predict a global reduction in areas for coffee cultivation of about 50 % mainly due to climate change. Today, production is challenged not only by climate change, but also high price volatility, low farmer's income, pests and diseases, rural depopulation and being replaced by more lucrative crops. Conversely, coffee consumption has been steadily increasing over the past decades, for example in China and countries in South East Asia, as well due to the global growth of the specialty segment. The NGO *Conservation International* extrapolates that demand for coffee will exceed the supply by a factor of three by 2050.

The Seattle-based startup *Atomo Coffee* might offer one solution to these complex problems. Atomo is the world's first molecular coffee, containing no coffee beans. The company has collaborated with the experts of the Coffee Excellence Center at the ZHAW, headed by Prof. Dr. Chahan Yeretzian, to create a naturally-derived and sustainable coffee that can be used in place of traditional coffee. The scientists of Yeretzian's group, Sara Marquart and Imre Blank, are using highly sophisticated analytical methods and strategies to reverse-engineer the coffee bean.

With the help of the Coffee Excellence Center, the goal is to build a consistently better cup of coffee that is also better for the environment, reducing the need for beans and thus minimising deforestation and destruction caused by commercial coffee farming and ensuring supply for the future of coffee. ■

Sustainable Chemical Processes through Catalysis

Competence Center for Biocatalysis (CCBIO)

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Plant fertilisers, electronic components, medicines and motor fuels – many everyday products result from chemical transformations. Establishing new strategies for sustainable chemistry is the focus of the new National Competence Center of Research "Suchcat" (Sustainable Chemical Processes through Catalysis), which is based at the ETH Zurich and at the EPF Lausanne and will be supported with 17 million Swiss Francs of federal funding (2020–2023).

The national network also involves the Competence Center for Biocatalysis at the Institute of Chemistry and Biotechnology. The CCBIO team will focus on the discovery, computer-aided optimisation and application of enzymes for the valorisation of renewable feedstocks and the manufacture of molecules with societal benefits. By tailoring the environmentally benign biocatalysts for chemical production, CCBIO will contribute to Suchcat's aim to create the scientific and technological bases to make chemical processes and products, and indeed the chemical industry more sustainable, resource-efficient and CO_2-neutral. ■

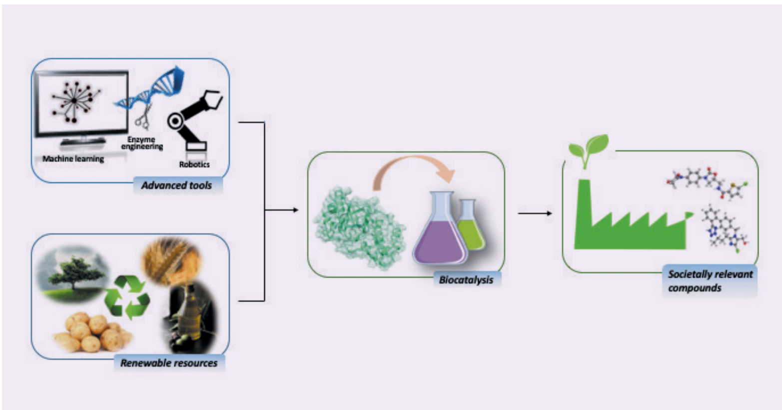

Fig. 1: Within the framework of the NCCR Suchcat, the CCBIO team will use advanced tools of bioinformatic and enzyme engineering to tailor biocatalysts for the sustainable manufacture of societally relevant compounds.