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PRESSEMITTEILUNG

Bioeconomy 360°:
The bread of the future

Stable quality despite climate change, less fertilizer, efficient bakeries, a healthy diet, waste recycling: Interdisciplinary approach to the bioeconomy at the University of Hohenheim using the example of bread

The bioeconomy is a team effort: Research approaches from a wide range of disciplines interact to ensure a successful shift towards a sustainable and viable economy. Using the example of "bread", it is possible to glimpse what this looks like in concrete terms at the University of Hohenheim in Stuttgart: from the breeding of new cereal varieties that defy climate change, the ecological footprint of bakeries and nutritional aspects, to the utilization of old baked goods for the production of bio-plastics – a 360° view of the "Bread of the Future" on the occasion of the Science Year 2020|21 Bioeconomy.

Climate change: Challenge for breeding

At present, no one can say for sure which flour will be used to bake our bread a few decades from now.

The focus of breeding is on high-performance varieties with high yields and sufficient protein content, because the latter ensures that the bread dough is fluffy and pliable – and easy to process. These criteria will continue to be important in the future. However, climate change as well as environmental problems due to over-fertilization constitute an ever-increasing challenge.

For example, a research project conducted in two phases up to 2018 as part of the Research Group 1695 "Regional Climate Change" at the University of Hohenheim has caused a stir. Among other things, scientists grew wheat in climate chambers that simulated the temperatures and CO2 levels of the year 2050.

In principle, CO2 has a beneficial effect on the growth of plants, as the greenhouse gas acts like a fertilizer. However, this is at the expense of quality: the model plants had significantly lower protein content. There were also decreases in the content of nutrients, such as calcium, iron, magnesium, and zinc. The concentrations of amino acids were likewise up to 11 percent lower.

Robust varieties: Improved understanding of the impact of the environment

Researchers from various disciplines are working closely together in the search for robust cereal varieties of tomorrow that will exhibit stable quality under changing environmental and cultivation conditions.

The "BETTERWHEAT" project, which began in winter 2019/20 at the University of Hohenheim in collaboration with the Mainz University Medical Center and the breeding companies DSV, Limagrain, KWS and WvB, is one of the world's larger projects focusing on wheat quality, with a funding volume of around EUR 1 million.

Around 300 different wheat varieties are being cultivated in 4-8 different growing regions and closely scrutinized in this project. In addition to criteria such as yield, disease resistance, dough and baking properties, the study also analyzes which varieties offer the best profile for human nutrition.

The crux of the matter: All of the above criteria are subject to considerable variation depending on environmental influences and variety selection. But only those characteristics that are mainly influenced by variety and less by the environment can be successfully influenced in the value chain.

"BETTERWHEAT is one of the first studies to delineate the impact of variety and environment on so many traits," explained project leader apl. Prof. Dr. Friedrich Longin from the State Plant Breeding Institute at the University of Hohenheim. "Here we are doing pioneering work that is of major relevance for domestic wheat breeding and the development of new wheat products. It will also improve our overall understanding of the impact of environmental factors on cereal quality. To do this, we combine state-of-the-art genomics, proteomics, spectrometry methods, and climate data."

A race against time: Can digitalization help?

In the context of climate change, breeders are also looking, amongst other things, at the factor of heat and drought stress. This is because periods of drought, like the ones we have already experienced in recent years, are becoming more frequent and more extreme.

The problem: Breeding new cereal varieties is traditionally a slow process that takes many years. But the clock is ticking – and the race against climate change is unlikely to be won with conventional methods.

Digitalization, among other things, promises help: "We are working on using DNA databases and biostatistical methods to optimize the search for the most promising 'parents' for a cross – and thus significantly accelerate the breeding process," said Prof. Dr. Karl Schmid, Director, Department of Crop Biodiversity and Breeding Informatics.

An important goal of breeding research is also to arrest the depletion of the gene pool. This is because only a broad genetic base will make it possible to rapidly produce adaptable cereal varieties in the future that will be able to cope with more extreme weather conditions and periods of drought, for example, and thus ensure food for future generations.

Diversity: What potential do old species offer?

Consumers also want more variety. For example, old species such as einkorn, emmer and spelt are in high demand. This is because they have convincing features such as their flavor and inherent values, for instance a high mineral content.

However: There are numerous peculiarities both in the cultivation and processing of the varieties that almost fell into oblivion. Over the past two years, the University of Hohenheim has conducted what is probably the world's largest field trial with ancient cereals.

"We have grown 150 varieties each of einkorn and emmer, and about 100 varieties of spelt, on small plots in our test sites. The focus was on disease susceptibility, yield, and dough and baking properties, among other things. Our conclusion: the successful re-establishment of old varieties is possible. But it depends, among other things, on whether a stable value chain can be created," reported apl. Prof. Dr. Longin.

Improved baking properties – less fertilization: What makes for a good cereal?

The criteria used to measure the quality of cereals also urgently need to be put to the test, according to Hohenheim experts.

"So far, the protein content of cereals was seen as the determining factor. This is because storage proteins, also called 'glutens', make the dough elastic and pliable through a network of tiny air bubbles. Large retail chains therefore draw up precise specifications for the protein content of flour, which thus becomes the decisive factor for the price of cereals," explained Prof. Dr. Christian Zörb from the Department of Quality of Plant Products.

The high protein content is achieved not only by breeding appropriate high-performance varieties but also, and above all, by fertilization. The rule of thumb is: the more nitrogen there is in the field, the more protein there will be in the wheat. However, this can lead to serious environmental problems, such as contamination of near-surface groundwater. Moreover, the world's phosphorus reserves are coming to an end – and are distributed very unevenly around the globe. Politicians responded in 2020 with a new Fertilizer Ordinance, but some of these regulations pose major challenges for farmers.

"We therefore want to really get to the bottom of the relationship between protein content and baking quality," said Prof. Dr. Zörb. "Initial trial results showed that it is not so much the total amount of protein that is decisive, but above all the composition and quality of the proteins. We estimate that more accurate knowledge about which varieties and how much fertilization it actually took to produce the desired traits can help to reduce nitrogen fertilization by a quarter in wheat production worldwide."

Flour quality: Can innovative technologies help?

If the quality of cereals is to be determined in more detail in the future, not only in research but also in the milling and cereal industries, new technologies are required for this purpose that can be used in a practicable and cost-effective manner. The Department of Process Analytics and Cereal Science is therefore working on establishing a spectroscopy method. In addition to the concentrations of protein and starch, the aim is in particular to predict the baking properties, which up to now could only be reliably determined by means of elaborate baking tests.

In order to compensate for natural fluctuations in protein content and to improve the kneadability of low-gluten or gluten-free flour, further innovative strategies are also required. One possibility in this context could be, for example, treatment of the flour with cold plasma or ozone.

"The cold plasma and the ozone strengthen the protein network in the flour through oxidation, which makes the dough elastic and viscous. The treatment is residue-free – only the oxidized molecules remain in the dough. Flour treatment agents, which otherwise take over the oxidation, are therefore no longer necessary," explained Prof. Dr. Bernd Hitzmann from the Department of Process Analytics and Cereal Science.

Intolerances and irritable bowel problems: What makes bread easy to digest?

Consumers are also increasingly interested in the ingredients in their bread. Many people suspect, for example, that the high gluten content of wheat bread leads to intolerances. However, from a nutritional point of view, it is worth taking a closer look at this.

"In fact, spelt bread, for example, which many people consider particularly digestible, has a much higher gluten content than a typical wheat bread. A decisive factor here could also be the exact protein composition. We are currently investigating this in a human study," said Prof. Dr. med. Stephan C. Bischoff of the Institute of Clinical Nutrition.

In patients with irritable bowel syndrome, on the other hand, a group of carbohydrates and sugar alcohols known as FODMAPs can cause discomfort. Their content in bread depends, among other things, on the rising time of the dough.

"In one study, we were able to show that bread whose dough was allowed to rest for less than two hours contained a particularly high concentration of the problematic FODMAPs. However, an even longer rising time did not result in a significant further reduction. Nevertheless, the long dough proving process can have a positive effect on the aroma and quality of the bread – and the minerals it contains may be more readily available," said Prof. Dr. Bischoff.

Ecological footprint: How do bakeries operate efficiently and sustainably?

A current project at the Department of Process Analytics and Cereal Science is taking a comprehensive look at all the important processes that take place in a bakery. Computer models will help to optimize processes in such a way that energy consumption and CO2 emissions will be minimized and, as far as possible, no food waste will be produced.

"Among other things, we want to improve machine capacity utilization by identifying individual steps that cause delays in operation. At the same time, a forecasting tool will help to estimate the required quantities more accurately. Algorithms calculate the potential demand for certain products based on, for example, weather data, typical vacation periods, and old sales data," reported Prof. Dr. Hitzmann.

Old baked goods: Raw material for plastics of the future?

As long as waste cannot be completely avoided in bakeries, the question of how to recycle it as sustainably as possible will continue to arise: As non-food biomass, old bakery products could be

an interesting feedstock in the future, for example, to produce the platform chemical HFM and biochar in biorefineries.

"HFM serves as the starting point for the bioplastic PEF. As a petroleum-free alternative to PET, PEF can be used to manufacture bottles or synthetic fibers such as nylon, for example. At the Biorefinery Technology Center of the University of Hohenheim, we are currently researching how the technical process can be optimized to make it economically viable. In this way, these products might have a chance of rapidly pushing fossil products out of the market and of contributing to climate and environmental protection," reported Markus Götz, a doctoral candidate and research associate with the Department of Conversion Technologies of Biobased Resources headed up by Prof. Dr. Andrea Kruse.

The nutrient-rich solution, which is produced as a residue in the biorefinery, will, in turn, be processed by a biogas plant and returned to the field. The biochar can also be reapplied as a fertilizer and soil improver. In this way, spoiled old baked goods could help to grow cereals for new baked goods – a cycle in keeping with a bioeconomy.

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