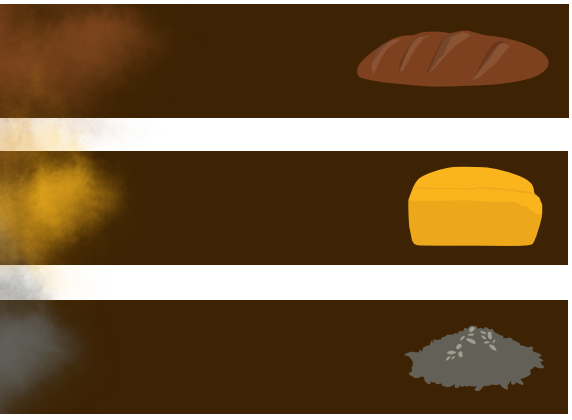
“We will be able to produce baked goods with completely new characteristics.”

Mario Jekle

The most popular bread types in Germany in percent (in 2017)



32.8
Mixed wheat and rye breads

20.3
Bread for toasting

14.9
Granary and seeded breads

Bread from the printer

What gives bread its bite? What are the processes that create a crunchy crust and lend a loaf its soft crumb? Using a 3D printer, TUM researchers are unlocking the secrets of baking bread and paving the way for fast, flexible production in the future.

For thousands of years, man has baked bread. And there are thousands of different recipes and methods of doing so. They are all are based on combining water and flour – starch and proteins – before fermenting the mixture and heating it in an oven. This transforms the dough into a fragrant loaf with a soft crumb and crunchy crust. But why does this happen?

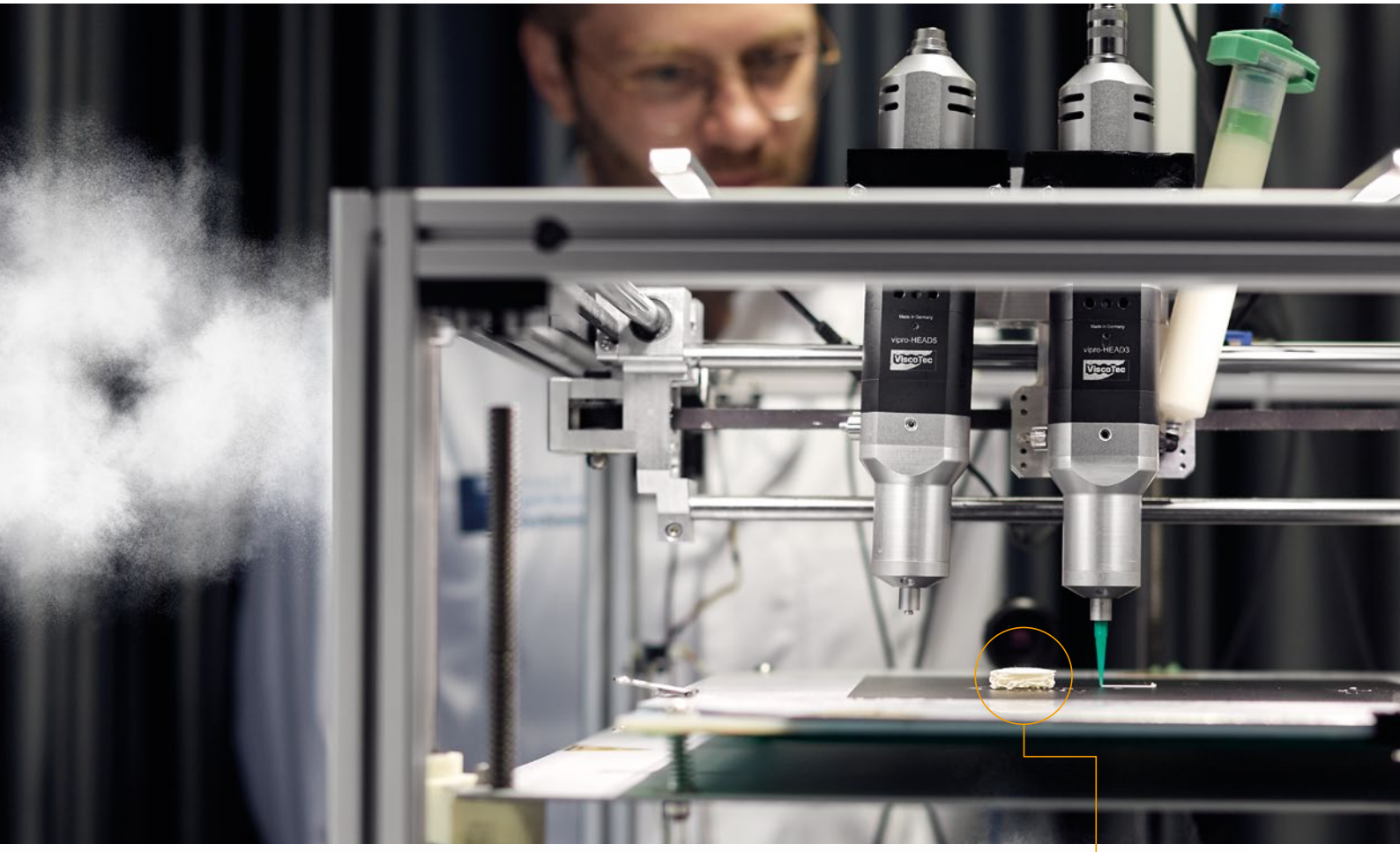
"To this day, we still do not fully understand the complex processes involved in baking," says Dr. Mario Jekle of the Chair of Brewing and Beverage Technology at TUM, which is headed by Prof. Thomas Becker. Several dozen parameters influence the outcome – including the composition and particle size of the ingredients, the ability of the proteins to polymerize and the volume of water added, as well as process parameters such as the temperature of the oven.

In their laboratory at the TUM School of Life Sciences, Jekle and his team examine the interactions between these factors. "To do this, it is important not to bake under standardized conditions; instead, we have to decouple the processes," emphasizes food technologist Jekle. "In a conventional oven, this isn't possible. That's why we use 3D printing technology."

At the moment, the new process is only capable of baking small bread rolls hardly larger than a sugar cube. Nothing in this process, however, is left to chance: Every ingredient is chemically analyzed and weighed before being kneaded with water into a sort of dough in a miniature mixer. The printer then turns this dough into bread – without using yeast or any other leavening agent and without waiting a long time for the bread to rise.

▷

Picture credit: unsplash/Mike Keneally; Graphics: ediundsepp



The researchers have been working to investigate the printability of dough and optimize the process for three years. "Applying the dough evenly represented a major challenge: The tough, elastic mass of flour and water needs to be squeezed through a funnel, the deposition, without the narrow opening of barely a millimeter wide becoming blocked," explains Jekle, the Head of the Chair's Cereal Technology and Process Engineering research group.

Over time, the researchers have perfected the system. As the print head whizzes back and forth, it produces thin threads of dough, placing new threads beside the last, until an area of 1 square centimeter has been covered. A laser beam then scans the layer of dough, with its heat ensuring that the proteins combine and create a stable structure. Once this "transformation" is complete, the print head places the next layer on top – leaving spaces for pores to form. After 5 minutes, the bread cube is finished. The researchers have already printed hundreds of these miniature bread rolls.

To date, the 3D printer has only baked very small bread rolls; however, it makes it possible to guarantee the same baking conditions each time and decouple the individual processes. Mario Jekle (in the background) and his team have optimized the process.

The characteristics of a loaf of bread depend on its ingredients, the ability of the proteins to form networks, and the baking temperature. Jekle and his team analyze crust and crumb at their bread research lab.

Every cube is different and contains different proportions of starch and proteins, different pore sizes, and are heated to a greater or lesser degree to create the crusts and crumb. Jekle's team measures the compressive strength, moisture loss, weight and porosity of each cube. The samples are sent to the TUM Chair of Food Chemistry and Molecular Sensory Science for analysis of their fragrance and taste. Joining forces, the research teams now hope to examine the extent to which porosity and flavor release are interrelated. Jekle plans to use the results to develop a mathematical model that can depict the baking process. Simulations will enable the examination of issues such as how a bakery can achieve the best results with the lowest energy input, as Jekle explains: "To do this, we need to model how much heat is required for the structure to stabilize."

The 3D printing technique also opens up new possibilities in terms of product development: "In a few years, there will be bread printers for domestic use and small bakeries, as well as for clinics that need to comply with dietary requirements," predicts Jekle. "We will be able to produce baked goods with completely new characteristics – with soft exteriors and crunchy pieces of crust on the inside, with or without certain proteins. Production in 3D printers makes it possible to adapt to the customer's wishes quickly and easily."

■ *Monika Weiner*

Picture credits: Franziska Schroedinger; Graphics: ediundsepp