INDUSTRIAL DEVLOPMENT PROJECTS

In-situ time-resolved 3D imaging of cell-formation during convection baking of bread, with or without microwaves

THE INDUSTRIAL CHALLENGE

For baking of bread with energy-efficient technology without compromising on quality, the food industry needs deeper understanding of how the ingredients and baking procedure interact and impact the properties of the bread. The latter are closely linked to the development of crumb structure, but the complexity of the baking process makes it challenging to analyze bread structure in real-time. Extracting the samples for analysis at different times would interrupt the baking, making it impossible with such a method to track changes in a single sample. Microwave heating has the potential to speed up production and save energy, but this rapid process adds further challenge for in situ analyses.

WHY USING A LARGE-SCALE FACILITY

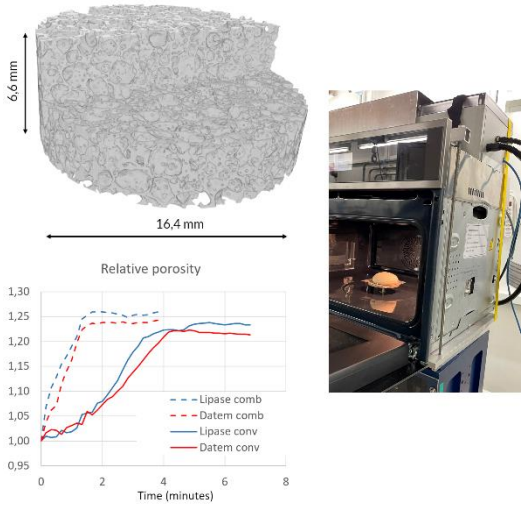
X-ray microtomography (μCT) is non-destructive and enables imaging of the microstructure of bread. Lab-based μCT may be used in a static condition, but with the time-resolution needed for in-situ imaging during baking, the X-ray flux of synchrotron facilities, SRμCT is needed.

HOW THE WORK WAS DONE

A sample environment in the form of an Electrolux combination oven, had its *pulsed* power supply (1 kW on/off) replaced by one that can supply *continuous* microwave power (between 0,2 and 1 kW). The purpose was to enable imaging of the complete baking process for microwave-convection baking. The SRμCT imaging was done at the TOMCAT beamline, Paul Sherrer Institute (PSI) Switzerland. It was performed with 11 μm per pixel and 1 s per 3D scan, recorded in the middle of the bun. The field-of-view (width x height) was 16,4 x 6,6 mm, resulting in 1488 x 1488 pixels. Dr. Federica Marrone at PSI is acknowledged for invaluable support during the experiments. Dough preparation done by Lantmännen guaranteed integrity of all scanned doughs-to-bread. Starting from a wheat benchmark recipe, variations were made with regards to content of salt, oat flour, Datem, Lipase, wheat fiber and wholegrain. Conventional convection baking was also part of the study.

THE RESULTS AND EXPECTED IMPACT

The whole microwave-convection baking process could be imaged. The evolution over time of some key parameters, such as cell wall thickness, mean pore size and porosity gave deeper insight into differences in dynamics between the two baking methods. Interestingly, combination baking in general resulted in less variations in the studied parameters. Another observation was that addition of lipase or Datem emulsifier (two kinds of dough improvers) seemed to result in different dynamics in pore development at convection baking.



Left: (Top) The reconstructed 3D image of bread crumb within the volume defined by the field of view and the sample rotation, and (bottom) the evolution of porosity during convection (__) and combined (- - -) for two dough improvers, lipase (blue) and Datem emulsifier (red). **Right:** The modified oven with bread, mounted at the TOMCAT beamline.

"The synchrotron imaging gave us better visualization of how bread structure developed through the baking process"
/Rune Gerner Møller , Lantmännen

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Vinnova's project No: 2021- 03820 **Duration:** November 2021 -- April 2024

Funded by Sweden's Innovation Agency, Vinnova, in order to build competence and capacity regarding industrial utilisation of large-scale research infrastructures such as MAX IV and ESS.