INDUSTRIAL PILOT PROJECT

3D *in situ* visualisation of microwave-convective baking of gluten-free bread by time resolved SRμCT

THE INDUSTRIAL CHALLENGE

Gluten-free breads often do not reach the same quality as their wheat-based counterparts. They often obtain less volume and age faster, which in turn can be improved by adding modified potato starches. For the understanding of how the properties of different types of starches affect the time-dependent bubble formation that increases the volume, it is important for the industry to be able to analyse different part of the baking process in real time.

WHY USING A LARGE-SCALE FACILITY

The structure evolution i.e. pore, and lamella extension occur rapidly during baking. Thus, synchrotron radiation microscale computed tomography (SRμCT) with high temporal and spatial resolution is vital in order to perform *in situ* experiment.

HOW THE WORK WAS DONE

Gluten-free doughs based on a benchmark recipe of Garbo Food, with the addition of different potato starches (native or modified) from Lyckeby, Sveriges Stärkelse-producenter were produced and fermented at the TOMCAT beamline at the Swiss Light Source of Paul Scherrer Institute (PSI), Switzerland. An Electrolux oven sample environment of RISE, allowing both convective and microwave baking, was used and samples were analysed during microwave-convective or convective baking. The SRμCT analyses were performed in situ during baking with 11 μm pixel size and 1 s per 3D scan. The field-of-view (width x height) was 16.4 mm x 6.6 mm, resulting in 1488 x 1488 pixels. The 3D structures were recorded in the middle of the bun. In order to estimate quantitative image parameters, e.g. porosity, pore size and lamella thickness, a combination of Matlab and Python was used. Dr. Federica Marone at PSI is acknowledged for invaluable support during the experiments.

THE RESULTS AND EXPECTED IMPACT

With synchrotron data, pores and the bread material in the form of lamellae were visualized and distinguished very clearly, and the pore size, porosity (i.e. proportion of pores) and thickness of the lamellae were all quantified in 3D. A surprising structure development of the gluten-free bread was the stalled increase of porosity during convective baking followed by a decreased, see figure. This indicates a slight collapse of the pores, which may be due to the lack of gluten that can hold the pore structure together. Combination baking with microwaves, on the other hand, shows a continuous increase in porosity throughout the baking process. Gluten-free bread with modified starch addition showed a somewhat higher porosity and thinner lamellas compared to addition of native starch using combined baking.

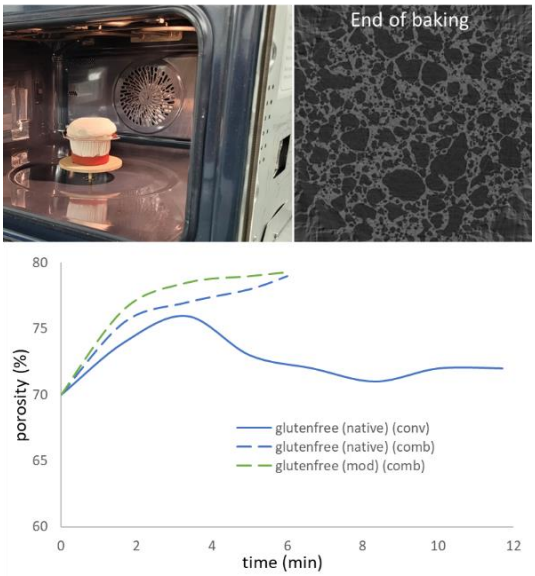

Figure. Top: the modified oven and a microtomography image of benchmark recipe gluten-free bread after baking. Bottom: porosity vs. time for gluten-free bread during baking using convection or a combination of microwave-convection with addition of native or modified potato starch.

Since much of the bubble expansion apparently occurs already during fermentation, the next step would be to investigate the fermentation step *in situ*.

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