PREPARATORY INDUSTRIAL PROJECT

Visualisation in situ of resource-efficient microwave-convective baking of gluten-free bread using x-ray and neutron tomography

THE INDUSTRIAL CHALLENGE

The main challenges in industrial baking of gluten-free bread are related to achieving desired bread volume and shelf-life due to loss of network-building capacity from gluten which leads to loss of elasticity. The hypothesis is that it is possible to make gluten-free bread with good properties by optimizing formulation, using tailor-made starch, and processing conditions. However, information about the effect of the time-dependent distribution of water between gluten and starch and the effect of starch properties on the time-dependent bubble formation during baking is lacking. Understanding of water migration can potentially also increase the valorization value of bread products in terms of perceived freshness and extended shelf-life.

WHY USING A LARGE-SCALE FACILITY?

Synchrotron-based x-ray tomography with high temporal resolution is vital to understand the time-dependent bubble formation and the bread forming process during baking since it takes about 2 – 15 minutes to go from a dough to a finalised bread, depending on baking technology. Neutron-based techniques will help to increase the level of understanding of water migration in bread during baking. The sensitivity of synchrotron SAXS/WAXS measurements are needed to be able to study the detailed structure of the starch during baking.

THE RESULTS AND EXPECTED IMPACT

The project identified synchrotron-based x-ray tomography and neutron tomography to study the impact on achieved bread volume of gluten-free bread by using a) advanced microwave-convective technologies for baking of gluten-free bread, combined with b) modified starch ingredients. Two bakeries were involved to better understand the challenges in baking gluten-free bread also from the baker's point of view. A tailor-made oven with windows for x-rays and neutrons, which only fits to certain beamlines that has space for the oven and large enough field of view of the x-rays will be used. The very short baking time at resource-efficient microwave baking puts special requirement on high temporal resolution on the beamline. The TOMCAT beamline, PSI, Switzerland, and/or at P05, DESY, Germany, are identified since they have space enough for the oven and good temporal and spatial resolution. Moreover, the neutron imaging facility at Oak Ridge (Neutron Imaging Facility | Neutron Science at ORNL) is identified for the water migration studies since they have performed similar studies in foods before. Based on literature and previous experience, it was concluded that practical experiments to evaluate an appropriate contrast medium are recommended, with the aim to enable and improved visualisation in complex structures like bread matrices. For the SAXS/WAXS measurements, the oven will be stopped and samples will be taken out. Future ForMax at Max IV, or BL11 – NCD-Sweet at Alba, Spain, are identified as suitable beamlines for these studies based on their material science character. Initial baking trials were performed and an initial experimental design where the dough ingredients have been prioritised has been developed.

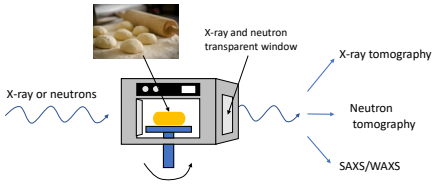

Figure 1. Illustration of baking of gluten-free bread

"För oss är det intressant att visualisera våra produkters funktion, hur man kan spela med olika modifieringar och produkttyper för att nå önskade egenskaper på slutprodukten." Kalle Johansson, Sveriges Stärkelseproducenter, förening u.p.a.

Contacts: Kalle Johansson – Sveriges Stärkelseproducenter, förening u.p.a., kalle.johansson@lyckeby.com
Birgitta Raaholt – RISE Research Institutes of Sweden, birgitta.raaholt@ri.se

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