

Bread baking simulations: an attempt to take into account formulation and partial-vacuum baking technology to reduce baking temperature and optimize bread quality

BEDRE-DINE S. (1), LUCAS T. (1), GRENIER D. (1)

1 INRAE, Rennes, France

Bread baking is one of the most energy demanding food processes and bakers have become increasingly concerned with the need of optimization tools to better control raw material fluctuations and reduce baking energy consumption. Although numerical modeling still does not cover all the complexity of the phenomena involved during baking, we think that numerical modeling can help R&D. Modeling makes it possible to approach phenomena that are difficult or impossible to isolate/disentangle experimentally and at lower economic and environmental costs. In response to the lack of literature dealing with the prediction of bread texture from physics-based models [1], this study attempts to use multiphysics simulations of baking as a supporting tool for studying the impact of both process and formulation parameters on overall expansion, bread crumb density and spatial gas fraction heterogeneities.

The numerical simulations were conducted using a finite element model that has previously been experimentally validated on French baguettes. The model takes into account CO₂ yeast's production below 40°C and its desolubilisation from the liquid phase during heating, liquid and water vapor, and air. The dough deformation is governed by both gas production and the evolution of the mechanical properties of dough during baking. Gravity and shrinkage due to water loss as well as gas cell opening and evapo-condensation-diffusion are also considered.

A reference simulation at atmospheric pressure first helped us to deepen the phenomena involved in the aeration or densification of the crumb. Then the study mainly focused on the combination of different yeast gas productions, and modified starch gelatinization/gas cell opening temperatures with baking at lower temperatures than those usually used in conventional baking. These simulations suggested some interesting paths when combined with partial-vacuum baking. A lowering of external pressure of only 5 kPa positively influenced the overall expansion and crumb density was 8% reduced compared to that baked at atmospheric pressure.

[1] Purlis, Emmanuel, Cevoli, Chiara et Fabbri, Angelo, 2021. Modelling Volume Change and Deformation in Food Products/Processes: An Overview. *Foods*. avril 2021. Vol. 10, n° 4, pp. 778. DOI 10.3390/foods10040778.