Alveolar structure of bread dough and rheological properties of its constitutive phases.

Arnaud Turbin-Orger, Laurent Chaunier, Hubert H. Chiron, Guy G. Della Valle

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A. Turbin-Orger[#], L. Chaunier, H. Chiron, G. Della Valle

INRA, UR 1268 Biopolymères, Interactions & Assemblages (BIA), BP 71627, 44316 Nantes
[#] Corresponding author. Mail address : arnaud.turbin@nantes.inra.fr

Bread doughs of various compositions were prepared and the evolution of their cellular structure during proofing was studied by computed X-ray microtomography (XRT) with high resolution (5 µm). The cellular structure was followed during the last stage of proofing, from 40 min to 180 min, to focus on the films separating bubbles and their possible coalescence. Images analysis allowed to determine the porosity, the connectivity index, the bubbles size and the cell walls thickness distributions which were fitted by usual mathematical functions. Images showed that different compositions led to different cellular structures. The kinetics of porosity and connectivity had sigmoid shapes with 0.7 and 1 as asymptotic value, respectively. For an standard formula, mean cell diameter grew from 410 µm to 675 µm and the mean cell walls thickness grew from 200 µm to 230 µm. At the end of proofing most bubbles were interconnected, *i.e.* they were separated by films of thickness lower than 5 µm. Changes of recipe led to different structures and were discussed regarding the influence of the liquid fraction and the sugar content on the coalescence of bubbles. These results suggested that at the end of proofing, the dough could be considered as a three-phases co-continuous medium: gas / liquid / viscoelastic matrix. In this context, the aim of this study was also to determine the role of each on the evolution of the cellular structure, particularly the role of thin films, separating the cells. Elongational behavior of dough was characterized by lubricated squeezing flow. Elongational properties, consistency and flow indexes of the dough, were influenced by the formulation. The volume fraction of liquid increases the heterogeneity of the cellular structure. Connectivity of the gas cells that may arise during proofing before steric hindrance did not limit their free growth. The elongational properties of dough, alone, did not explain the influence of formulation on the cellular structure. The liquid phase of dough seemed to have an important role too. The dough liquor (DL), could be considered as a good model of this liquid phase. To clarify its role, it was extracted from the dough by ultracentrifugation and its rheological properties were analyzed for various amount of water, sugar and oil. Its density (≈ 1.1) was less than that of the hydrated starch-gluten matrix (≈ 1.25). DL is a yield stress fluid, its viscosity was essentially modified by the sugar content, while its surface tension was close to 40 mN / m and its foaming properties underlined the role of fat and sugar on the foam stability.

Keywords: bubbles, films, X-ray microtomography, image analysis, liquid phase, bread dough.