Experimental Setup for Measuring Bread Physical and Chemical Properties During Baking

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Bread baking is a complex process subjected to chemical (e.g., Maillard reactions) and physical transformations (e.g., water loss and volume expansion). Those chemical reaction products give desirable color and flavor to food. However, they can generate contaminants such as 5-(Hydroxymethyl)-2-furfural (HMF), harming human health. This study built a finely controlled cavity to measure physical changes in bread baking and correlate process variables, bread physical properties, and HMF formation throughout the cooking process. The temporal evolution of temperature, humidity, mass loss, volume, porosity, core structure, color change, and HMF content was evaluated. The proposed experimental system presented longitudinal symmetry, ensuring greater control of the alterations suffered by bread. The bread lost 11, 15, and 17% moisture for baking at 180, 200, and 220 °C, respectively. Moisture loss occurred near the crust, while the central region increased up to 4.2%. Volumetric expansion in the baking was higher at lower temperatures, i.e., 27.6% at 180 °C, 23% at 200 °C, and 23.5% at 220 °C. The evolution of color presents a sigmoid profile for all parameters of the CIE L*a*b* space. A proposed model described the kinetics of the color development as a function of temperature with good values of R2 and RMSE. The HMF content is related to temperature from the power function with an R^2 of 0.9713. The formation of HMF does not occur until the bread crust reaches 150 °C. The HMF content is also related to color parameters, occurring when the crust of the bread reaches the maximum yellowing (b*) and luminosity values (L*) below 60. The proposed models described the formation of HMF according to the color parameters L* and b* with good R^2 (0.9713 and 0.9635, respectively), which allows the prediction of the HMF content from the color of the bread. The correlations obtained under controlled cooking conditions accurately predict the properties of the bread for each cooking configuration, allowing the design and optimization of the oven cavity.