
Unravelling food thermal reactivity by an original methodology to analyze and model reactions during baking of a model cake

LEE J. (1), ROUX S. (2), REGA B. (2), BONAZZI C. (2)

¹ INRAE, Institut Agro, STLO, Rennes, France

² Université Paris-Saclay, INRAE, AgroParisTech, UMR SayFood, Palaiseau, France

In baked foods, formulation and process steps lead to the generation of a multitude of compounds responsible for quality through the activation of thermal reactions. However, determining the link between composition, reactivity and quality determinants is not an easy task because of the interdependency of physical and chemical parameters and the complexity of real ingredients.

Therefore, studying transformations in a food matrix under strictly controlled physical, structural and chemical conditions is of paramount help to verify the hypotheses formulated by many decades of results obtained in simple model systems (far from real foods) or in real products (with limited understanding on specific reaction pathways).

Using a model cake with a structure and manufacturing dynamics comparable to those of a real cake and containing only controlled amounts of defined precursors (glucose with/without leucine), two observable reaction patterns could be built and compared to experimental kinetic data measured on numerous markers (precursors, intermediates and products). Volatile markers were sampled from baking vapors by an on-line sampling device and quantified by TD-GC-MS while non-volatile markers were extracted from the cakes and quantified as follows: reducing sugars by UHPLC-CAD, free amino groups by titration, dicarbonyl intermediates by UHPLC-MS, furfural and 5-hydroxymethylfurfural by UHPLC-DAD. Temperatures (oven and in-cake) and water content were monitored during baking under controlled heat treatment conditions (3 temperature set-points and 2 convection levels).

The results showed that the impact of convection on the reactions was very limited compared to that of temperature and formulation. The caramelization and Maillard reaction pathways with glucose and leucine as precursors were clarified and consolidated. Formation of glyoxal and diacetyl from 1-deoxyosone could be neglected. Leucine acted on the Maillard reaction which overpowered the eneaminol-induced caramelization of glucose. The importance of isomerization of glucose to fructose was also highlighted. The kinetic evolution of furfural and 5-hydroxymethylfurfural was modeled in both the matrix and the vapors, paving the way for possible quantification of many volatile markers for kinetic modeling. These data constitute a complete and original database, which can be useful for the construction of stoichiometric kinetic models and the quantification of the preponderance of specific reaction pathways.