Modeling Maillard Reaction and Thermal Transformations During Bread Baking

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Introduction: Modeling of foods and cooking processes represents an advanced topic for food industries and research institutions. Predicting and optimizing flavors is still a major issue. A coupled thermal and kinetic model can help to face this aim.

Figure 1. Photo of the bread after baking. Core temperature measurement.

Thermal Model: The hot air enters the oven from the 4 inlets and is suctioned from the central outlet to be reheated in the back.

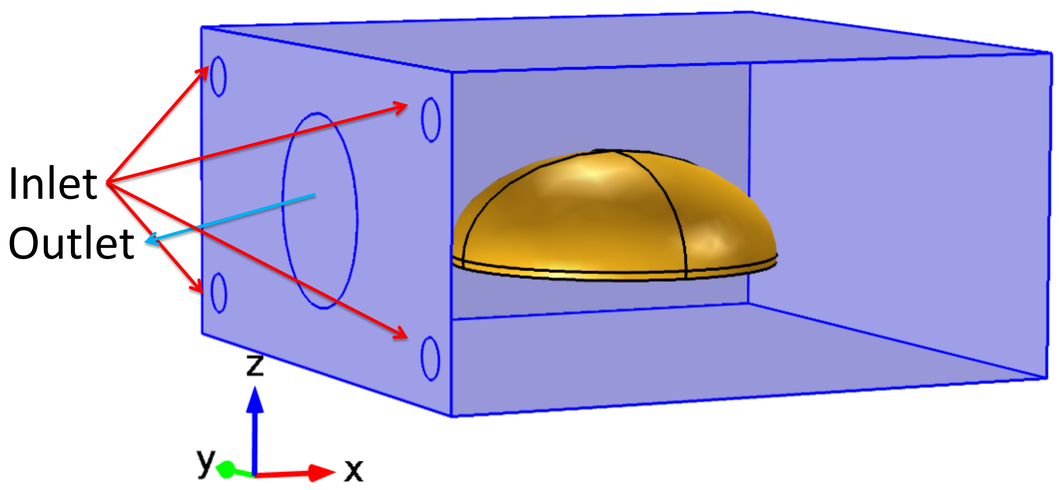

Figure 2. Cavity and Bread design

Bread is considered homogeneous material with temperature dependent properties that take account for the dough to crumb and crust transition (Purlis and Salvadori, 2009)

$$k(T) = \begin{cases} 0.9/[1+\exp(-0.1(T-353.16))]+0.2 & \text{if } T \leqslant T_f - \Delta T \\ 0.2 & \text{if } T > T_f + \Delta T \end{cases}$$

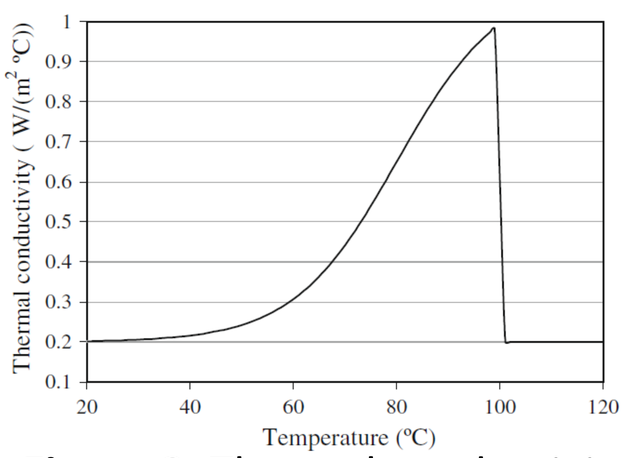

Figure 3. Thermal conductivity

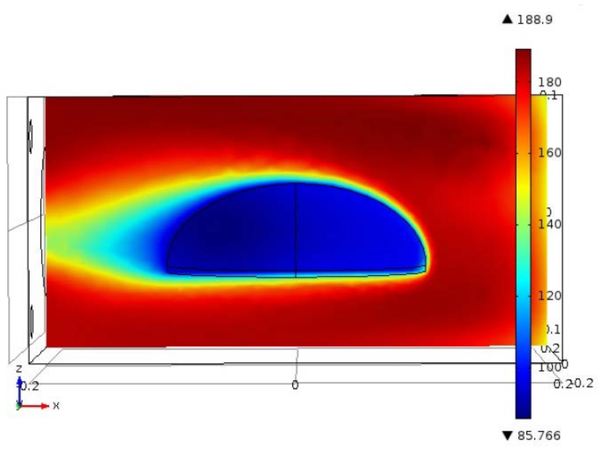

Figure 4. Thermal profile

Kinetic Model: The used Maillard kinetics comes from a paper of (Jousse et al, 2002). It consists on several reactions between compound classes.

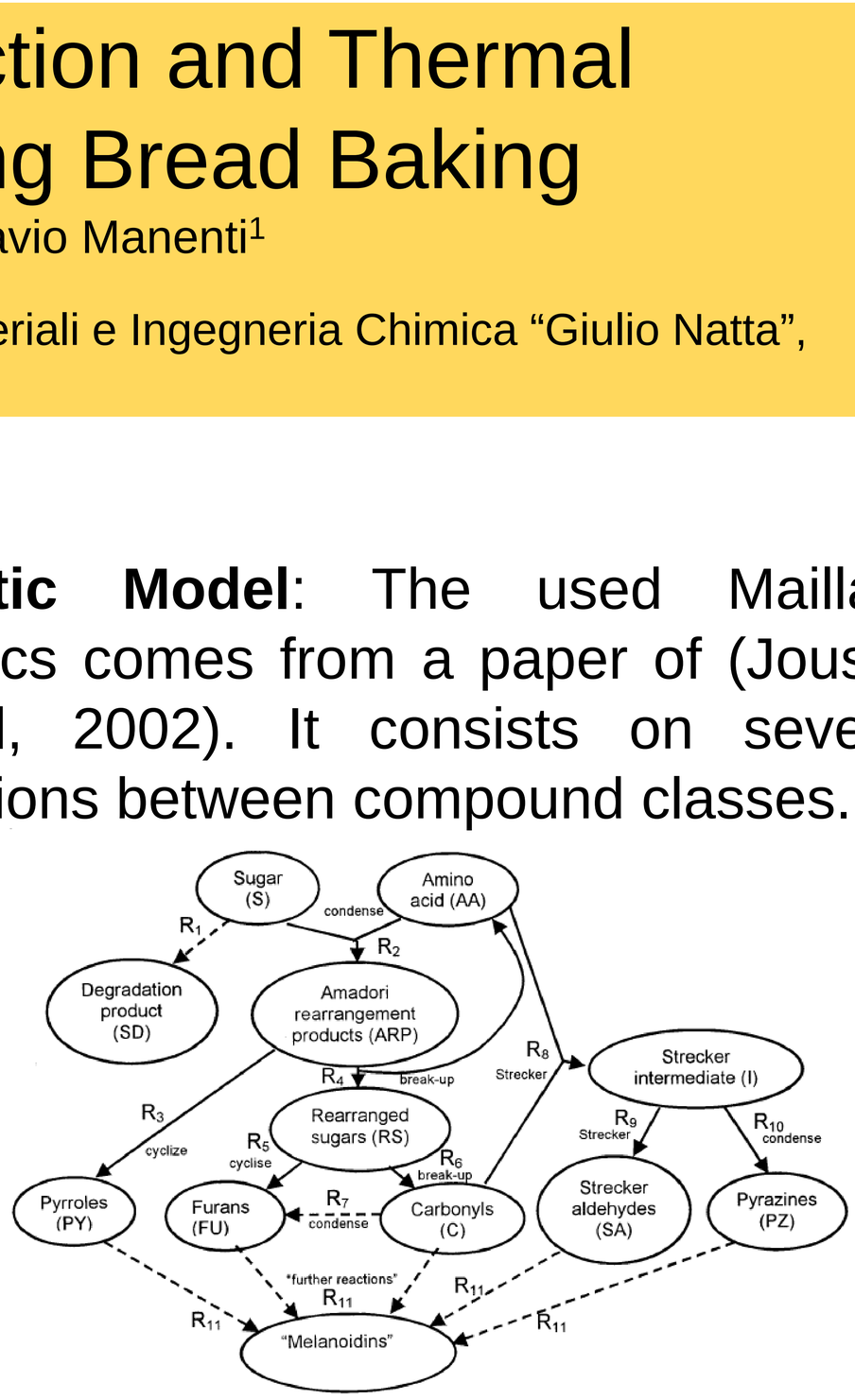

Figure 4. Simplified Maillard Reaction path

Results: The thermal model is validated under experimental data and gives the basis for the flavor development simulation. The coupled model gives first indications of the kinetics of the several flavor compounds and confirms the development of Melanoidins as one of the final products.

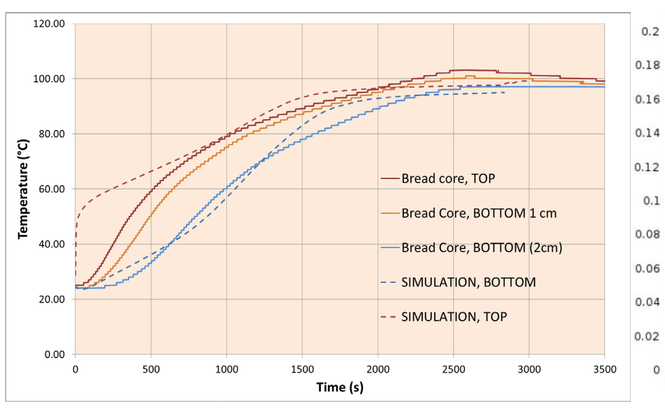

Figure 5. Bread core temperature

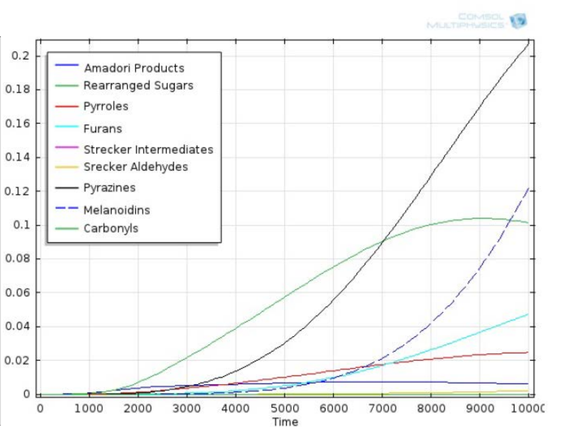

Figure 5. Flavors profile

Future developments: The kinetic model will be improved with more classes and extended to the non-volatile species. Experimental measures will be performed for validation purposes.

References:

1. Purlis, E., Salvadori, V., 2009, Bread baking as a moving boundary problem. Part 2: Model validation and numerical simulation, Journal of Food Engineering , 91 (3), 434–442
2. Jousse, F., Jongen, T., Agterof, W., Russell, S., Braat, P., 2002. Simplified kinetic scheme of flavor formation by the Maillard reaction. Journal of Food Science, 67, 2534-2542.

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