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Quality prediction of bakery products in the initial phase of process design

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Abstract

The development of food production processes is facilitated by tools which explore the interaction between process design, operation conditions and product characteristics. In this work an approach how to set-up a simulation model is presented for the phenomena and transformations which occur during baking and which fix the product quality. The simulation model has three consecutive parts: mass and heat transport in the product, transformations concerning starch state transition and color, and the formation of quality attributes (color, softness, crispness and staling). The model for mass and heat transfer is based on laws of conservation and expressed in partial differential equations for spatial products. The starch state transition and color formation are a mixture of qualitative and quantitative information, while the product quality model is mainly based on qualitative information. The model is applied to three bakery products: bread, biscuit and a cake-type. The results show that the model estimates the product quality and its transformations as a function of dough composition, baking and storage condition. The results fit well to observed changes of properties and product quality during baking.

Keywords: Baking; Heat mass transfer; Product quality prediction

Industrial relevance: Food industries require tools to evaluate processing options in the feasibility phase of process design. Therefore, simulation of process models is important for this purpose. However, knowledge of different aspects is subject to area of expertise (for example heat and mass transfer versus product quality formation) and often these areas are hardly connected. This work presents a systematic modeling approach for the dominant processes during baking and their interconnection. The main functions of the model are to explore the consequences of choices in design, to rank design options and to find in what direction properties will change when operational conditions change. Moreover, the model can be used for sensitivity analysis to explore on what items further information must be gathered.

1. Introduction

Nowadays, the life cycle of products in the food industry decreases and new or modified products are more frequently introduced to the market. As a consequence, the period for product and process development becomes shorter. Modification of old products or introduction of new products starts by making an inventory of desired product quality. Next, a feasibility study defines the main concept of the product and a global design for the production system. The feasibility phase allows creativity to explore several directions and searching for different alternative solutions. To be efficient in the feasibility phase a systematic working procedure is necessary. In the chemical industry the working procedures are supported by conceptual process design methodologies (CPD). This methodology is used in the chemical industry to find a description for the production plant through the following activities: arrangement of unit operations, routings of product and energy, the estimation of required process conditions, the composition of the streams and the required energy (Douglas, 1988; Siirola, 1996; Wibowo & Ng Ka, 2001). These procedures extensively rely on process models for the analysis, evaluation and prediction of the physical state of the product.

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