Evaluation of acrylamide formation in potatoes during deep-frying: The effect of operation and configuration

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1. Introduction

In April 2002 unexpected high levels of the suspected carcinogen acrylamide (AA) were found in many heated foods, mainly represented by cereal and potato derivatives. As known acrylamide can form during intense heat treatments as a consequence of the reaction between asparagine and a carbonyl source via Maillard-type reactions (Zyza et al., 2003; Yaylayan and Stadler, 2005). Efforts by the scientific community have contributed to identify potential routes to reduce AA levels in foods and thus consumer exposure. These are relevant to agronomical interventions (i.e. selection of raw materials with low sugar and asparagine contents), and technological strategies, including pre-treatments (blanching, fermentation, use of asparaginase), as well as process (thermal input and moisture control) and recipe (use of organic acids, polyvalent cations or amino-acids) changes.

Reviews of AA and ways for reducing its level in foods have been published by Friedman (2003), Stadler and Scholz (2004), Taeymans et al. (2004), Friedman and Levin (2008) and Anese et al. (2009). Also, the most relevant mitigation strategies are summarized in the Toolbox presented by the Confederation of the European Food and Drink Industries (CIAA, 2009). Recent contributions to chemical modeling can be found in Knol et al. (2009) and De Vleeschouwer et al. (2009).

Much interest has been already attracted by multiple and interdependent transport phenomena during food frying, as in Farid (2001) and Farid and Kizikel (2009), but the related results have been limited to one-dimensional modeling and dependence upon empirical transfer coefficients. Similarly, some food engineering research has been recently presented on AA-forming processes, but with a focus on average parameters only (Palazoglu and Gökmen, 2008; Gökmen and Palazoglu, 2008). In this framework, process modeling has a fundamental importance, and can help to establish sounder knowledge when it emphasizes on both local and transient food features (Carriera et al. 2007, 2009). In this regard, computational fluid dynamics (CFD) models help gaining knowledge of critical processing variables, to improve the product safety and quality for generalized and particular process configurations alike.

With multiple transfer phenomena at stake, a proper modeling can be enforced by recalling the various governing equations (along with their boundary and initial conditions) and impose them on the whole product-bath system (conjugate approach). With this option, no loss of continuity is made for each transport mechanism (e.g. no need of empirical correlation for heat and mass at the product-bath interface). In addition, each transport mechanism may be strongly influenced by other ones: AA formation during food deep-frying is then seen as driven by a series of conjugate phenomena, as the transfer of species and heat to be solved simultaneously in both solid and fluid phases are strongly coupled through evaporation.