A Theoretical Model for the Control of Color Degradation and Microbial Spoilage Occurring in Food Convective Drying

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Abstract

Introduction
The aim of this work was the development of a predictive model aimed at identifying a proper control strategy of food drying process. In particular, it was intended to determine the effect of operating conditions both on the color degradation, chosen as a reference quality parameter, and on the microbial spoilage occurring during potatoes drying. A transport model, accounting for the simultaneous transfer of momentum, heat and mass occurring in the drying air and in the food sample, was formulated and coupled both to a product decontamination model, describing the microbial inactivation kinetics of Listeria monocytogenes and to another model aimed at predicting the kinetics of color changes occurring during drying. The proposed model allowed determining, on the basis of a dynamic optimization algorithm, a trajectory of operating conditions that has to be tracked by means of proper control systems so as to optimize the performance of drying process.

Conclusions
The proposed model represented a general predictive tool capable of describing the food drying process in those conditions in which internal evaporation was significant and could not be neglected. Heat and mass conservation laws, for both food and air, together with momentum transfer in turbulent conditions (for air only) were coupled, by means of a proper set of boundary conditions. The time evolutions of drying were predicted with no a priori limitation for irregular or complex-shaped systems.
The proposed model is particularly useful for those situations in which either semi-empirical correlations are not currently available (i.e. complex food geometries) or operating conditions are changed during drying process. Moreover, the model can also be used to determine which set of operating conditions would enhance the quality and the safety of the final product, thus minimizing expensive and time-consuming pilot test-runs. It is, in fact, possible to predict the spatial moisture profiles at all times, thus allowing the detection of the regions where either high values of moisture content or low values of temperature can promote microbial spoilage.
Finally, a proper optimization model was developed and, then, tested over a very wide range of operating conditions; a trajectory of operating conditions, actually variable with time, was eventually identified so as to achieve specific control objectives represented, for instance, by the determination of a trade-off condition between quality and safety.